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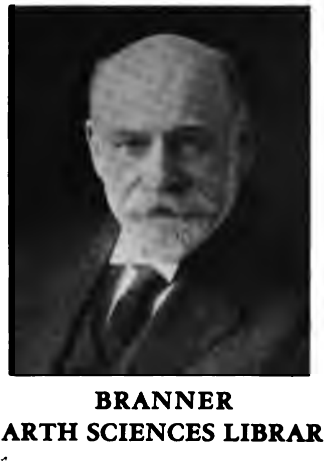

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ANNUAL REPORTS FOR 1910

PART IV

South Africa

GEOLOGICAL SURVEY

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OFFICE OF THE MINISTER OF MINES,
PRETORIA, 30th June, 1911.

SIR,

I have the honour to forward herewith the Annual Report of the Geological Survey for the year ended the 31st December, 1910.

The attached Index Map shows the progress that has been made with the mapping during the year, which is described in detail in the Report of the Director.

It will be observed that, as anticipated in my last Report, the total area mapped is much less than that completed during 1909, but this is due largely to the work undertaken on the Witwatersrand, and to vacation leave taken during the year by two members of the staff.

The mapping of the Witwatersrand area, referred to in my covering minute of last year, was commenced by Dr. E. T. Mellor in January, 1910, but, owing to the detailed and complicated nature of the work, especially in its preliminary stages, the progress made is necessarily slow. Besides the vast amount of material which has to be considered, an average of approximately three and a half miles of boundary lines for every square mile of area is being traced, the usual average in other portions of the country being about half a mile per square mile. Where an accurate large scale map is available, mapping is being done on a scale of approximately four inches to the mile, with a degree of accuracy and detail not possible on the smaller scale usually employed for other districts, the great intricacy and importance of the geology of this area being the reason for the greater detail in which it is being mapped. Outside the municipal area of Johannesburg a smaller scale is being employed of about one inch to the mile.

Dr. Mellor appears to have proved in the course of this work the existence of a zone of severe faulting and folding, which affects considerably the sections across the lower Witwatersrand beds on the Central Rand.

A great deal of material has also been collected regarding the geology of the central portion of the town of Johannesburg. Owing to the gradual covering up of this area by the town it is extremely difficult now to obtain the data necessary to map it geologically. Advantage is, however, being taken of all excavations occurring in the town, and much of the surface geology has thus been pieced together. The process, however, being dependent mostly upon scattered observations, is necessarily a slow one. The whole of this work, although slow at the commencement, is laying the foundation of the work for the other sections of the Rand, and will probably considerably expedite the survey of the areas on each side of it, when they come to be undertaken.

It is hoped that it will be possible to extend the Witwatersrand work into the Klerksdorp and Potchefstroom area, a considerable portion of which has already been done by the Survey.

A large scale map of about one hundred square miles, including Johannesburg and its environs, which will ultimately be published, will, apart from technical considerations, have a distinct educational value.

The following sheets of the Geological Map of the Transvaal were issued and published separately :—

Sheet No. 5. Zeerust.
„ „ 6. Mafeking.

The following sheets are completed and will be issued shortly :—

Sheet No. 7. Potgietersrust.
„ „ 8. Sekukuniland.
„ „ 9. Marico.

The mapping of the following sheets will probably be completed during 1911 :—

Sheet No. 10. Nylstroom.
„ „ 11. Pilandsberg.
„ „ 12. Lydenburg.
„ „ 13. Olifants River.

The Sekukuniland Sheet was completed during 1909, and it was also stated in the Report for that year that the Nylstroom and Pietersburg Sheets were to be issued shortly. During the past year, however, having regard to the desirability of extending the work of the Survey after the completion of Union to other Provinces, you decided to somewhat modify the original method proposed for the division of the Transvaal Provinces for the purposes of the sheet maps, and it has now been arranged that each sheet shall in future be bounded by the meridians and parallels, a method which will facilitate considerably the extension of the mapping into the other Provinces. The new sheets are arranged so as to embrace an area equal to that of half one of the degree sheets issued by the Surveyor-General's Department, the only difference being that the east and west boundaries of the Geological Survey sheets will coincide with the 30′ meridians instead of the full degree meridians. This arrangement is found to adapt itself more satisfactorily for important centres such as the Witwatersrand, the whole of which will thus fall into one sheet.

This arrangement of the sheet maps does not materially affect those already published lying immediately north of the 26th parallel; northward of this series, however, the new sheets will necessarily include somewhat different areas from the old ones. Thus, in the case of the new Nylstroom Sheet, the north-west corner now falls on ground which has still to be completed, and in the case of the Pietersburg Sheet the town of Pietersburg falls into a new sheet, only the southern portion of which has so far been mapped. The area, however, which has been completed to the south and south-west of Pietersburg, is now included in the recently issued Potgietersrust Sheet.

Much of the Director's time was occupied during the year in visiting quarries in different localities of the Transvaal and the Free State, with the view of advising the Public Works Department on the subject of the most suitable building stones to be used for the various public buildings now in course of erection, and the results of these investigations are given by Mr. Kynaston in his Report.

As regards the policy being carried out under the programme for the new year, it may be mentioned that the Director has to revise certain portions of Sheet No. 2 (Pienaars River) for the publication of a second edition conformable to those of the new series. He will also complete the Nylstroom Sheet No. 10, and join up with Dr. Humphrey in the Rustenburg District, thus completing the outcrops of the Transvaal System for the Western Transvaal in the same manner as has been done for the system by Mr. Hall in the Eastern Transvaal. After the completion of this work he will continue the mapping of the Witwatersrand System on the West Rand, joining up with the work of Dr. Mellor.

The promising area in the south-eastern corner of the Transvaal in the neighbourhood of Piet Retief and on the main escarpment of the Berg has received not a little attention from prospectors during the past year or two, and promising indications of mineral values have been found. Very little systematic work has so far been done in this area, and in view of the railway development which is being carried on in that locality it has been decided by you that the Geological Survey should make a start with a systematic investigation of the area in question, carrying the survey across the Pongola into the north-eastern portion of Natal and Zululand, which really forms its true extension to the southward, and Dr. Humphrey will be detailed to take this work in hand as soon as he has completed the Pilandsberg area in the Rustenburg District, thus completing and compacting the work in that part of the country.

Following a similar line of policy, Mr. Hall has now been deputed to carry the detailed survey mapping down the Murchison Range and into the promising mineralized triangle between the Selati and Olifants Rivers, including the examination of the Palabora copper area and the mica deposits on the Olifants River.

The progress of the Selati Railway is already having effect in the district, and considerable ground has been taken up and held during the past year, and a fair amount of real

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development and prospecting work is being carried on in the locality. The sheet which will be published by the Survey of this area, with explanatory memoir, should assist prospectors as well as agriculturists who are interested in the very promising and hitherto inaccessible section of country lying north of the Olifants and towards the upper waters of the Letaba River.

Dr. Mellor some years ago made a rapid traverse of the Murchison neighbourhood, which has been useful as a preliminary to more detailed mapping.*

The work in the Barberton area referred to in my Report of last year will necessarily not be carried out until the completion of this work in the north.

The newly appointed geologist, Dr. Wagner, will, as soon as he has made himself acquainted with our main typical geological sections, accompany and assist other members of the Field Survey for a few months, and will ultimately undertake the mapping of the area lying between Middelburg and Belfast, thus completing the linking up of the Pretoria and Lydenburg Districts.

The areas mapped by the Survey since its reorganization in 1903 are given below :—

Year.	Area in Square Miles.	Cost of Survey for the Year.	District.
1903	1138	£6277	Pretoria and Middelburg.
1904	3167	5502	Pretoria and Waterberg, Middelburg and Waterberg, Pretoria.
1905	3778	6671	Barberton, Waterberg, Pretoria and Middelburg, Lydenburg, Pretoria and Rustenburg.
1906	4963	6544	Pretoria and Witwatersrand, Middelburg, Lydenburg, Carolina, Pretoria and Rustenburg.
1907	4915	6541	Potchefstroom, Lydenburg, Zoutpansberg, Rustenburg and Witwatersrand, Waterberg and Rustenburg.
1908	6089	6645	Waterberg, Southern Zoutpansberg, Rustenburg and Marico, Lichtenburg.
1909	5300	6657	Waterberg, Sekukuniland, Pilgrims Rest and Pietersburg, Western Transvaal and Klipriviersberg.
1910	4154	6811	Witwatersrand, Lydenburg and Middelburg, Marico and Rustenburg, Potchefstroom and Witwatersrand.

The following table shows the areas completed by the Geologists during the year, together with the number of linear miles of geological boundary lines traced upon the field maps :—

	Square Miles Surveyed.	Linear Miles of Boundary Lines Traced.
E. T. Mellor	120	410
A. L. Hall	1839	674
W. A. Humphrey	2195	2090
TOTALS	4154	3174

The number of miles travelled during the year, apart from travelling by rail, was as follows :—

	By Wagon.	Driving, Riding, and Walking.
H. Kynaston	—	505
E. T. Mellor	—	3300
A. L. Hall	710	1755
W. A. Humphrey	431	1750
TOTALS	1141	7310

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* See Geological Report for 1906.

A list of all the publications issued by the Geological Survey is printed at the back of this volume for reference.

The staff for the year under review was as follows:—

Director	H. Kynaston, B.A., F.G.S.
Geologists	E. T. Mellor, D.Sc., F.G.S. A. L. Hall, B.A., F.G.S. W. A. Humphrey, B.A., Ph.D.
Curator	S. M. Tweddill, F.G.S.
Chief Clerk and Librarian	P. M. O'Connor.
Draughtsman	E. H. B. Banks.
Laboratory Assistant	C. C. Gardthausen.

In addition to the temporary assistance that was necessary in the drawing office, a temporary assistant was also engaged to assist Dr. Mellor in the intricate work on the Rand.

The main heads of the cost of the work during the twelve months ended the 31st December, 1910, were as follows:—

Salaries and allowances	£5516
Transport and subsistence	684
Public Works Department (heavy transport)	410
Museum and Laboratory and miscellaneous expenses	201
	£6811

I have the honour to be,

Sir,

Your obedient Servant,

H. WARINGTON SMYTH,

Acting Secretary for Mines.

To the Honourable
The Minister of Mines,
Pretoria.

MINES DEPARTMENT,
GEOLOGICAL SURVEY OFFICE,
PRETORIA, 14th June, 1911.

SIR,

I have the honour to submit herewith the Annual Report of the Geological Survey for the year ended 31st December, 1910.

It comprises a general report of the work done, followed by the more detailed and special reports of the field staff on the results of the geological investigation and mapping of the different areas assigned to them.

I am, Sir,
Your obedient Servant,
H. KYNASTON,
Director, Geological Survey.

The Acting Secretary for Mines,
Pretoria.

CONTENTS

PAGE

I.—DIRECTOR'S REPORT 13

II.—THE GEOLOGY OF A PORTION OF THE CENTRAL WITWATERSRAND, by E. T. Mellor (*Geologist*) 23

III.—THE GEOLOGY OF THE STEELPOORT RIVER VALLEY, INCLUDING THE COUNTRY ROUND ROOSSENEKAL AND DULLSTROOM, by A. L. Hall (*Geologist*) 39

IV.—THE GEOLOGY OF THE RUSTENBURG AND ZEERUST BUSHVELD SOUTH OF THE DWARSBERG, by W. A. Humphrey (*Geologist*) 63

V.—THE TRANSVAAL SYSTEM WEST OF THE KLIP RIVER VALLEY, by W. A. Humphrey (*Geologist*) 81

VI.—ADDITIONS TO THE MUSEUM AND LIBRARY 91

APPENDICES :—

A.—Table showing the crushing strength of various South African Sandstones, Granites, etc. 103

B.—Table showing the specific gravity, weight per cubic foot, and absorption of various sandstones 105

C.—Table showing the different kinds of stone used in various buildings in Pretoria, Johannesburg, etc. 106

LIST OF ILLUSTRATIONS

PLATE
I.—Index Map of the Transvaal, showing area mapped up to end of 1910 (Frontispiece).
II.—Fig. 1.—A portion of Steenpan Quarry, near Coalbrook, Orange Free State.
Fig. 2.—A portion of Steenpan Quarry, near Coalbrook, Orange Free State.
III.—Fig. 1.—A portion of Flatpan Quarry, near Coalbrook, Orange Free State.
Fig. 2.—Balmoral Stone Quarry, Kromdraai, near Balmoral.
IV.—Fig. 1.—Bayswater Stone Quarry, Bloemfontein.
Fig. 2.—A portion of Bayswater Quarry, Bloemfontein.
V.—Fig. 1.—Red Sandstone Quarry, Buiskop, near Warmbaths.
Fig. 2.—A portion of Buiskop Quarry, near Warmbaths.
VI.—Fig. 1.—Waterval Stone Quarry, 14 miles north of Pretoria.
Fig. 2.—Red Granite Columns, quarried at Hammanskraal, north of Pretoria.
VII.—Fig. 1.—Bon Accord Quarry (Norite), 10 miles north of Pretoria.
Fig. 2.—A portion of Bon Accord Quarry.
VIII.—Junction between top of Pretoria Series and Norite Margin of Bushveld Complex, near Oshoek No. 1442, Lydenburg District.
IX.—Sekukuni Mountains (Bushveld Granite). View looking westwards from the right bank of the Steelpoort River on Steynsdrift No. 16, Lydenburg District.

MAPS AND SECTIONS AT END OF REPORT.

X.—Map of Central Witwatersrand.
XI.—Map of portions of Middelburg and Lydenburg Districts.
XII.—Map of portions of Marico and Rustenburg Districts.
XIII.—Map of portions of Marico and Rustenburg Districts.
XIV.—Map of portions of Krugersdorp, Potchefstroom, and Heidelberg Districts.

FIGURES IN THE TEXT.

PAGE
Fig. 1.—Section across the valley of the Waterval River, showing the succession near the top of the Magaliesberg Quartzite series.............................. 49
Fig. 2.—Section across the valley of the Lydenburg Dorp River, showing the horizon of the altered limestone.. 52
Fig. 3.—Generalized section across the valley of the Steelpoort River on Steynsdrift No. 16, Lydenburg District.. 57
Fig. 4.—Generalized section from Tauteshoogte across the Blood River Valley to Bothasberg 58
Fig. 5.—Sections AB and CD on Map, Plate XIV, illustrating the folding and faulting described on pages 84 and 85...................................... 84
Fig. 6.—Sections from the Syferfontein Coalfield, on Syferfontein No. 32, Krugersdorp.. 89

I.

DIRECTOR'S REPORT

FOR THE YEAR 1910

CONTENTS

Distribution of the Field-Work.

General Review and Summary of the Field-Work.

- (1) *Work on the Witwatersrand.*
- (2) *Lydenburg and Middelburg Districts.*
- (3) *Marico and Rustenburg Districts.*
- (4) *Potchefstroom and Witwatersrand Districts.*

Economic Geology.

- *Building Stone.*

Publications—

- (*a*) *Official.*
  - *I. Maps.*
  - *II. Memoirs and Sheet Explanations.*
- (*b*) *Un-official.*

I.—DIRECTOR'S REPORT.

1. Distribution of the Field-Work.

During the year 1910 the work of the Geological Survey in the eastern and western Transvaal was continued by Messrs. Hall and Humphrey respectively, while the mapping of the central Witwatersrand was commenced by Dr. E. T. Mellor. A small tract of country was also mapped by Mr. A. L. Hall in the Woodbush and Haenertsburg area, east of Pietersburg, the results of which, however, are being at present held over, pending the completion of the whole of the Murchison Goldfield. A portion of the Springbok Flats, lying between Zebedela's River and the Pietersburg Railway was also mapped by the same geologist, in order to complete the survey of the southern portion of the Potgietersrust Sheet.

In the southern Transvaal, in addition to the work in progress on the Witwatersrand, a small area was mapped by Dr. W. A. Humphrey, situated to the south-west of Johannesburg, partly in the Potchefstroom and partly in the Witwatersrand District. This was a continuation of the work already carried out by him during 1909 in the Klip River Valley.

In the eastern Transvaal, in continuation of the work already completed in that part of the country, Mr. A. L. Hall surveyed a considerable area, situated partly in the Lydenburg and partly in the Middelburg District, including Mapoch's country and the upper portion of the valley of the Steelpoort River, to the north-west of Dullstroom. In the south-western portion of this area, Mr. Hall joined up with the work completed by Dr. Mellor in the Middelburg District in 1906.

In the western portion of the Province, Dr. W. A. Humphrey carried the mapping of the Marico River Valley down to the Dwarsbergen, and on the west as far as Ramutsa, on the border of the Bechuanaland Protectorate. A large area in the Rustenburg District was also completed by him east of the Marico River.

The Director was absent on vacation leave during portion of the year. During the summer months, in addition to the usual work in the office, he was occupied in examining various quarries in different parts of the Transvaal and Orange Free State, on behalf of the Public Works Department, in connection with the construction of the new Government offices in Pretoria, and other public buildings. He also made an examination of various sections on the central Witwatersrand in company with Dr. Mellor, in connection with the numerous problems of Lower Witwatersrand stratigraphy.

2. General Review and Summary of the Field-Work.

During the year satisfactory progress was made with the mapping, though owing to the necessarily detailed and intricate nature of the work on the Witwatersrand, the total area completed, namely, approximately 4000 square miles, was considerably less than that completed during the preceding year. When one or more geologists are stationed on the Witwatersrand, or engaged in the detailed mapping of Witwatersrand rocks, it will naturally be impossible to cover anything like the same area as when the whole staff is occupied in the outside districts. It is hoped, however, that with the appointment of an additional geologist early in 1911, more rapid progress will be made and that the work of the Survey will be extended from the south-eastern Transvaal into Natal.

Two additional sheet maps of the Geological Map of the Transvaal were completed during the year, namely, No. 7-Potgietersrust, and No. 9-Marico, the position and extent of which will be seen by a glance at the Index Map at the commencement of the present Report.

(1) *Work on the Witwatersrand.*

The detailed mapping of the central Witwatersrand was commenced by Dr. E. T. Mellor in January, and an area of 120 square miles was completed, which involved the tracing of

410 miles of geological boundary lines upon the field-maps, or an average of approximately 3½ miles of boundary lines for every square mile of area.

The work of the year included the mapping of the Lower Witwatersrand System from the farm Witkopje No. 157 on the east to the township of Maraisburg on the west, a distance of approximately 23 miles. Where an accurate large scale map was available, as for instance within the municipal area of Johannesburg from the eastern boundaries of Observatory and Kensington Townships to near Maraisburg, the mapping was done on the scale of approximately 4 inches to the mile. Beyond the limits above indicated, the mapping was carried out in somewhat less detail on a scale of nearly 1 inch to the mile (1 inch = 5000 feet).

A large portion of the area mapped has proved to be exceedingly complicated, especially the neighbourhood of the Bezuidenhout Valley as far east as Rietfontein. Much new material has been added to our knowledge of this area, and fresh light has been thrown on the relationships of the Rietfontein Series and Langeman's Kop beds to the Lower Witwatersrand Series. A specially interesting point, however, that has been clearly demonstrated by Dr. Mellor, is the existence of a line of very severe faulting and folding, which has an important influence upon all sections across the Lower Witwatersrand System on the central Rand, and which will probably be found to be responsible for the many apparent differences and discrepancies observed in the sections presented by the central Rand, as compared with those of the western portion—differences which have hitherto been usually ascribed mainly to the varying thicknesses of the component beds.

An important part of the work of the year has been the collection of as much material as is available regarding the geology of the central part of the town of Johannesburg. Owing to the almost complete occupation of this area by streets and buildings, it is no longer an easy matter to map it geologically, and it will probably be a considerable time before an accurate plan can be completed of certain small areas in the centre of the town.

In addition to the mapping of the Lower Witwatersrand System, a portion of the area occupied by the upper division of the System to the south of Johannesburg has also been mapped on a corresponding scale.

(2) *Lydenburg and Middelburg Districts.*

In this part of the country Mr. A. L. Hall mapped an area of 1433 square miles, including the tracing of 624 miles of geological boundary lines. The area lies mainly in the Steelpoort River Valley, north-west of Dullstroom, and west of Lydenburg, and includes the Steenkampsbergen and the Bothasberg. Magnetite deposits belonging to the norite zone are well developed in Mapoch's country, and may very possibly become of economic importance in the future. One of the most interesting features in the geology of the country is the discovery by Mr. Hall of a series of volcanic rocks between the Magaliesberg quartzite and the norite. These rocks cover a belt of country about 5 miles in width, and are in every respect similar to the amygdaloidal andesites of the Daspoort beds in the neighbourhood of Pretoria and other localities. Both series strongly recall the volcanic beds, termed Ongeluk Series by Dr. A. W. Rogers, which occur between the upper and lower Griqua Town beds in the north-western portion of the Cape Province.

A mass of elaeolite-syenite was also mapped, forming an intrusion in the Red Granite, and this is described in detail in Mr. Hall's report. The intrusion is mainly represented by foyaite-porphyries and aegerine-lujaurites, while forming an inclusion in these is a peculiar mass of altered dolomite.

(3) *Marico and Rustenburg Districts.*

In these districts Dr. Humphrey mapped an area of 1820 square miles, and traced 1710 miles of geological boundary lines upon the field-maps. The area lies in the western portion of the Bushveld basin, and includes the Dolomite and Pretoria Series, together with considerable areas of the Norite, Pyroxenite, and diabase, belonging to the Bushveld Plutonic Complex. The Dwarsberg, which belongs geologically to the northern portion of the basin, consists of the three quartzites of the Pretoria Series, the main range being formed by the Timeball Hill shales and quartzites west of Abjaters Kop, east of which, however, the double quartzites of the Daspoort beds form the most conspicuous features. The Magaliesberg Quartzites consist of six or seven thin bands, which form a considerable range in the western Dwarsberg, but thin out to the east, and do not form any prominent feature east of the Marico River.

Between the Marico River and the Pilandsberg the structure of the Bushveld syncline is somewhat peculiar, the evidence indicating that here the basin is shallow, and that the rocks exposed are not far from its floor, and illustrâte the breaking up of the Pretoria Series by the immense sheet of norite and other basic rocks, which preceded the intrusion of the Red Granite. On the northern rim of the basin in this part of the area, the Magaliesberg Quartzites are followed by a considerable thickness of altered shales, which are traversed by sheets of diabase and norite. These give place on the south to an irregular mass of shale and igneous rock, representing shale beds which have been invaded and broken up by the igneous rock which often surrounds large masses of them. These shales, as one would expect, are intensely metamorphosed. Along the southern margin of the basin the sedimentary beds are also much broken up by the igneous rocks, the upper quartzites and shales of the Magaliesberg beds being separated from the rest of the Pretoria Series, and now cropping out as isolated patches over the igneous area. The most considerable of these is represented by the Matlapynsberg.

(4) *Potchefstroom and Witwatersrand Districts.*

In continuation of his work in the Klip River Valley, carried out during 1909, Dr. Humphrey completed a further small area of 375 square miles, situated mainly to the west of the Klip River. The formations mapped were mainly Dolomite and the lower portion of the Pretoria Series, and the structure was found to be considerably folded and faulted. It is roughly synclinal in the eastern portion of the area, while the western portion is occupied by the northern arm of a syncline, the axis of which runs east and west through the Losberg. The southern portion of this syncline was described by Dr. Mellor in the Annual Report of the Geological Survey for 1907.

ECONOMIC GEOLOGY.

Building Stone.

With the exception of Dr. Mellor's work on the Witwatersrand, there is little to record bearing upon the subject of economic geology, as a result of the actual mapping undertaken during the year. Some attention, however, was paid to the question of building stone, more especially in connection with the various public buildings that had been provided for by the Government, and an examination was made by the Director on behalf of the Public Works Department, of various localities where it was expected that good freestones and granites might be obtained. A series of tests was also carried out upon a number of different sandstones and granites, partly in the Laboratory of the Geological Survey, and partly in the Mechanical Laboratory of the Mines Department in Johannesburg. These latter, the object of which was to ascertain the crushing strength of the different kinds of stone, were all carried out upon accurate two-inch cubes, prepared by the Curator of the Museum, and the results are given in Appendix A at the end of the present Report, together with a table showing the specific gravity, weight per cubic foot, and percentage of water absorbed. These should be of value in comparing the qualities of the different classes of South African stone. Several samples were also examined in thin sections under the microscope.

By far the greater proportion of the stone used for building purposes in the Transvaal, and probably all over South Africa, comes from the sandstones of the Karroo System. This one would naturally expect, since the Karroo formation shows a far less degree of disturbance and metamorphism than the older formations, which as a rule are only used quite locally and for limited purposes. Considering the enormous area occupied by the Karroo System, and the prevalence in it of thick beds of sandstone, one would not expect that the question of obtaining supplies of good stone should present any great difficulty. It is true that over large portions of the high veld country and the Orange Free State, stone of a fair average quality is easily obtainable, is used locally, and has been employed for railway buildings, bridges, etc., during the construction of the various railway lines traversing these areas.

On account, however, of the very variable character of many of these sandstones, it is no easy matter to find a really superior and reliable quality of stone in large quantities. Moreover, properly opened-up quarries are scarce, and there are very few large buildings in South Africa old enough for one to judge satisfactorily of the behaviour throughout long periods of time of the stone used. It should also be pointed out that practically all Karroo sandstones, and especially those associated with the Coal-measure Series contain varying proportions of felspar, a feature which cannot be said to be a favourable characteristic in a good building stone, but which at the same time is not so likely to be seriously detrimental in a dry climate like that of South Africa as in one like that of northern Europe.

A brief reference may now be made to examples of stone from different parts of the Transvaal and the Orange Free State, which have so far been used for building purposes. Perhaps one of the best known quarries and one from which the stone has been most widely used is that of Steenpan, situated near Coalbrook, in the Orange Free State. A thick bed of sandstone was opened up here some eighteen years ago in connection with the northward extension of the railway line from Bloemfontein, and has since then been largely used for building purposes in Johannesburg and Pretoria (see Appendix C), and recently Steenpan stone has been used for the new Law Courts, Johannesburg, and the new Post Office, Pretoria. The quarry at present shows a face of nearly 500 feet in length, the stone worked being from 8 to 10 feet in thickness. Apart from the labour involved in removing the over-burden, which has now attained a thickness of over 20 feet, the stone is easily quarried, and when fresh is comparatively soft and easy to dress. It is of a pale greyish colour and usually shows numerous short black streaks of carbonaceous material. These are, however, liable to weather more rapidly than the rest of the stone, and are often the cause of cracks in stones placed in unprotected portions of buildings. This stone was used in the construction of the Netherlands Bank, Pretoria, about sixteen years ago, and here it has weathered well; though in some cases, as for instance in the Lunatic Asylum, Pretoria, completed for some five or six years, its condition is by no means so satisfactory.

About 200 yards below the Steenpan Quarry, two other varieties of stone are quarried at the east end of a pan, the geological horizon being just below that of the Steenpan stone. These varieties are termed "Flatpan" and "Klippan", and differ from the Steenpan stone mainly in being somewhat closer in grain and considerably harder. The Klippan stone is also closely laminated with continuous black streaks, and though possessing considerable strength when placed on the natural bed, is only suitable for rough work.

The Flatpan stone is of a dull greyish colour, but very much superior to that from the Steenpan quarry in strength and durability. Its actual composition is on the whole similar, but the felspar grains and the cementing material are in a much better condition. The stone is also very uniform in character, with the exception of a peculiar kind of contorted false-bedding, which frequently makes its appearance. The thickness of this stone as at present quarried varies from 2 feet 6 inches to 3 feet, while it is both over and under lain by the laminated Klippan variety. It was used in the construction of the new University Buildings in Capetown about five years ago, where its appearance gives promise of considerable durability. It has also been employed for the new Station Buildings, Pretoria.

Belonging to a somewhat higher geological horizon, a massive bed of fine-grained grey sandstone about 15 feet in thickness has been quarried for some years at the Bayswater Quarries, three miles from Bloemfontein. The top three feet of the bed is much laminated, but below this the stone is very uniform in character, though occasionally somewhat mottled or speckled. It is a harder stone than Steenpan, and is somewhat expensive to quarry, though easy to dress. The usual method of quarrying is the same as that employed at Steenpan, blasting powder being used, and a number of charges being fired simultaneously from a small battery, the result being to move a huge mass of stone a few inches forward from the face, to be split up by wedges into rectangular blocks according to requirements. This stone has been used in Bloemfontein for the new Law Courts, the new portion of the Raadzaal, the new Government Buildings, and the new University College. A somewhat similar stone, but of inferior quality, from a neighbouring quarry, now abandoned, was used for the old Raadzaal, where it is not in a very satisfactory condition.

In the Transvaal various sandstones belonging to the Coal-measure Series, and in some cases to an horizon below that of the coal, have been quarried for some years past at various places, such as Balmoral, Ermelo, Elands River, Boksburg, Vereeniging, etc. Small quarries have also been opened for local purposes along the High Veld portion of the Delagoa Bay Railway, the Springs-eastward and Springs-Witbank lines, and the Natal line. To the north of Pretoria, the Coal-measure Sandstone is also worked at Waterval, near the old Rogerston Colliery, and at Hamanskraal. Many of these Transvaal stones, however, while otherwise satisfactory, are often spoilt by the presence of iron pyrites, and sometimes marcasite, in the form of small nodules, which may be locally concentrated to such an extent as to be seriously detrimental to the stone on exposure to the weather.

On the farm Kromdraai, near Balmoral, a thick massive bed of good white and greyish stone was quarried a few years ago, and was used to some extent locally. On the quarry being recently more extensively opened up, however, it was found that the good qualities indicated were not sufficiently maintained, and that a considerable proportion of the stone was affected by the presence of small pyritic nodules, which were liable to develop unsightly staining on weathering.

A hard white stone, possessing considerable strength, has been quarried at Elands River, but the stone varies very much both in hardness and texture, and often shows iron staining. The Ermelo stone is also hard, and of a pale yellowish grey, almost white, colour, but does not occur in sufficiently thick beds for blocks of large dimensions. This is largely owing to the flakes of white mica, which it contains, being frequently disposed horizontally, and so causing a tendency for the stone to split along them. It has been used for local buildings, fencing posts, gravestones, etc., and would probably be useful for paving.

In the neighbourhood of Boksburg several quarries have from time to time been worked, the two principal ones being those near the Rand Collieries, about four miles east-south-east of Boksburg, and that at the Rietfontein pan, near the Apex Mine. The stone from the former quarry is obtained from a bed about 16 feet in thickness, very massive, though occasionally rather broken by irregular joints. It is a pale grey stone, of very fair quality, though rather variable in texture, and often showing yellowish streaks. It is used largely on the mines for engine beds, etc., and makes a good material for grindstones. The stone used for the Carlton Hotel, Johannesburg, was obtained from a neighbouring quarry, now closed down. The stone quarried near the Apex Mine is of a similar general character, but laminated with narrow dark streaks, and cannot be obtained of a greater thickness than about 18 inches.

At Vereeniging, about 2 miles north of the town, a pale grey sandstone is quarried, and was used in the construction of Marks' Buildings in Capetown. It hardens considerably on exposure, but is strongly laminated and apt to turn a rather yellowish colour. The usual thickness obtained is about 18 inches. The stone used in part of the Palace of Justice, Pretoria, was from the same neighbourhood, but does not stand exposure to the weather at all well.

The stone quarried at Waterval, north of Pretoria, is a hard, very fine-grained, compact, rather yellowish sandstone, which on the whole stands the weather well, but no great thickness can be obtained, and it is frequently very streaky, and shows black and dark purplish stains. A pink variety was also taken out of the older portion of the quarry. The stone may be seen in numerous buildings in Pretoria, such as the National Bank, erected in 1892, the Government Buildings, the new University, etc.

At a considerably higher geological horizon of the Karroo System we have the Buiskop Sandstone, which is geologically the equivalent of the Cave Sandstone of the Drakensberg. The stone quarried at Buiskop, near Warmbaths, is a red variety and constitutes an effective, strong, and durable building stone. The stone mostly in favour is close grained and hard, somewhat expensive to work and dress, and frequently rather " plucky " in its behaviour. It contains a smaller proportion of felspathic material than the Coal-measure sandstones, the red colouration being due to a general staining of the constituent grains by iron-oxide. At present, however, there is no proper quarry at Buiskop, the stone being obtained by splitting up the large blocks and boulders which have fallen from the face of a krantz. These blocks frequently differ very considerably from one another in the quality of the stone, so that considerable labour is involved in looking for the most suitable class of stone, and even that supplied often varies considerably in hardness. It is very suitable for rock-faced work and for inside work when dressed.

At Middelkop, on the Springbok Flats, about 15 miles from Pienaar's River Station, a white variety of the same formation is quarried, but has not yet been used in any building of importance. It varies, however, very much in hardness, and the natural outcrop weathers in a very irregular manner, and to a rusty yellowish colour. It is quite possible, however, that a more uniform bed may be encountered as the quarry becomes more largely opened up.

In the Ladybrand and Ficksburg District, which was visited in April by Mr. A. L. Hall, a fine-grained sandstone, belonging to the same geological horizon has been largely used for local buildings, and may also be seen in the Railway Offices at Bloemfontein. The Ladybrand stone is very uniform in texture, very fine-grained, and of a pale cream colour; it occurs in unlimited quantities, is very massive, and practically free from divisional planes. Large dimensions can be obtained, and the stone is adapted for any kind of dressed work. In Ladybrand it has been exposed in several buildings for twenty years and more, and has on the whole stood the weather well. Occasionally, however, there is a considerable darkening of the colour on the exposed surface. The stone also varies very much from place to place, and usually shows small black specks, probably due to oxide of manganese. There is at present no properly opened-up quarry, the stone being obtained by breaking up the large blocks which have rolled down from the krantz, which forms the main outcrop of the bed. The best quality of the Ficksburg stone, which is of a rather whiter colour than that of Ladybrand, is now exhausted, and only inferior varieties are in use.

With regard to granites and other igneous rocks, used for building and ornamental purposes, very little of this class of material, with the exception of the granite of the Cape Peninsula and De Paarl, has so far been worked in South Africa. In the Transvaal the grey granite, which occurs between Pretoria and Johannesburg, is quarried on the farm Witkoppen, about 14 miles north of Johannesburg. This is a medium-grained biotite-granite, the disposition of the minerals of which tend to a somewhat parallel arrangement, so that there is usually a well defined grain, along which the stone can be split more readily than in any other direction. The stone is used for ornamental work, granite sets, curbing, steps, etc., and may be seen in the basement portion of the Union Buildings, Pretoria.

A slightly coarser variety of granite, and of a more pinkish colour, is quarried at the Halfway House, on the Pretoria-Johannesburg main road. The stone can be split fairly easily in almost any desired direction, and practically any size can be supplied. It has been used in the new Station Buildings, Pretoria. Other varieties from the same granite mass have been quarried in other localities such as Craighall, and close to the Jukskei River Bridge, and used locally, but they are of a very variable character.

A coarse dark greenish diabase was quarried some years ago from large boulders to the north of Melville Township, near Johannesburg, and used in the Natal Bank in Johannesburg. A very handsome red syenite was also at one time worked to a limited extent near Bank Station, and may be seen in the National Bank Buildings, Pritchard Street, Johannesburg, in the steps of the Post Office, Johannesburg, and of the Palace of Justice, Pretoria.

To the north of Pretoria the norite (or black granite, as it is sometimes termed by quarrymen) forms a very hard and durable stone, very suitable for the basement portions of buildings, steps, curbstones, etc. A large quarry has now been opened in it at Onderstepoort by the Pretoria Municipality, and the stone has been used in the new Post Office, Pretoria. It also makes an admirable road-metal.

The Red Granite of the Bushveld occupies an enormous area in the central Transvaal, and though it shows considerable variation, varieties could probably be found locally, suitable for building and ornamental work. Some of the more acid types are often apt to disintegrate rather easily, but a hard and durable variety, containing rather less quartz than the commoner phase, was worked at Hamanskraal during the war for the construction of blockhouses, and has more recently been quarried for columns for the new Station Buildings, Pretoria.

PUBLICATIONS.

(*a*) *Official.*

I. Maps.—

The following maps were published during the year with the Report for 1909 on the scale of 2.35 miles to 1 inch, and illustrated by horizontal sections:—

(1) Portions of the Waterberg and Rustenburg Districts, including the country between Warmbaths and the Rooiberg, geologically surveyed by H. Kynaston (*Director*).

(2) A portion of the Waterberg District, including the country north and north-west of Nylstroom, geologically surveyed by E. T. Mellor (*Geologist*).
(3) Portions of the Middelburg and Lydenburg Districts, geologically surveyed by A. L. Hall (*Geologist*).
(4) A portion of the Lydenburg District, including the country north and north-west of Lydenburg, geologically surveyed by A. L. Hall (*Geologist*).
(5) A portion of the Marico District, geologically surveyed by W. A. Humphrey (*Geologist*).
(6) The Klip River Valley, geologically surveyed by W. A. Humphrey (*Geologist*).

II. Memoirs and Sheet Explanations.—

No. 5. The Geology of the Pilgrims Rest Gold Mining District, by A. L. Hall (*Geologist*).

The Geology of the country round Zeerust and Mafeking, including the Malmani Goldfields, and the Lead and Zinc Deposits south of Zeerust: An explanation of Sheets Nos. 5 and 6, by A. L. Hall and W. A. Humphrey (*Geologists*).

(*b*) *Un-official.*

The following contributions by members of the staff to scientific societies, etc., were made during the year:—

A. L. Hall.—Note on certain widespread ultra-acid rocks occurring along the margin of the Bushveld Granite in Western Sekukuniland, etc. Trans. Geol. Soc., S.A., Vol. XIII, pp. 10–16.

H. KYNASTON,
Director.

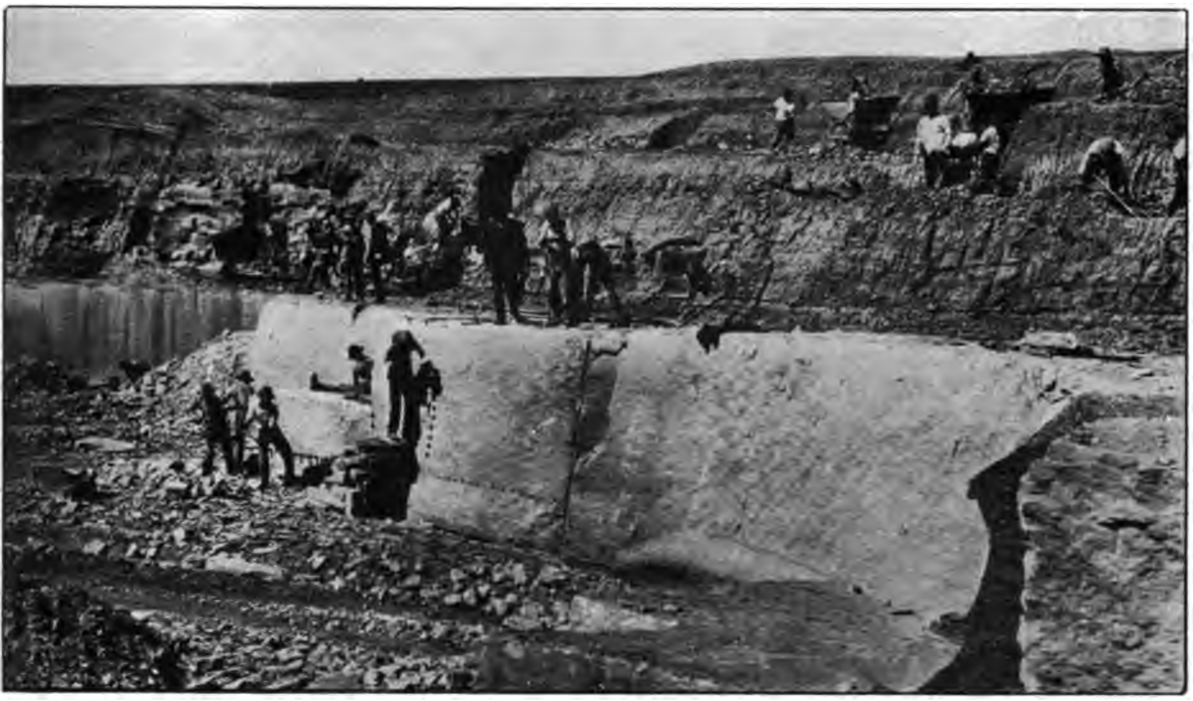

Fig. 1.—**A Portion of Steenpan Quarry,** near Coalbrook, Orange Free State.

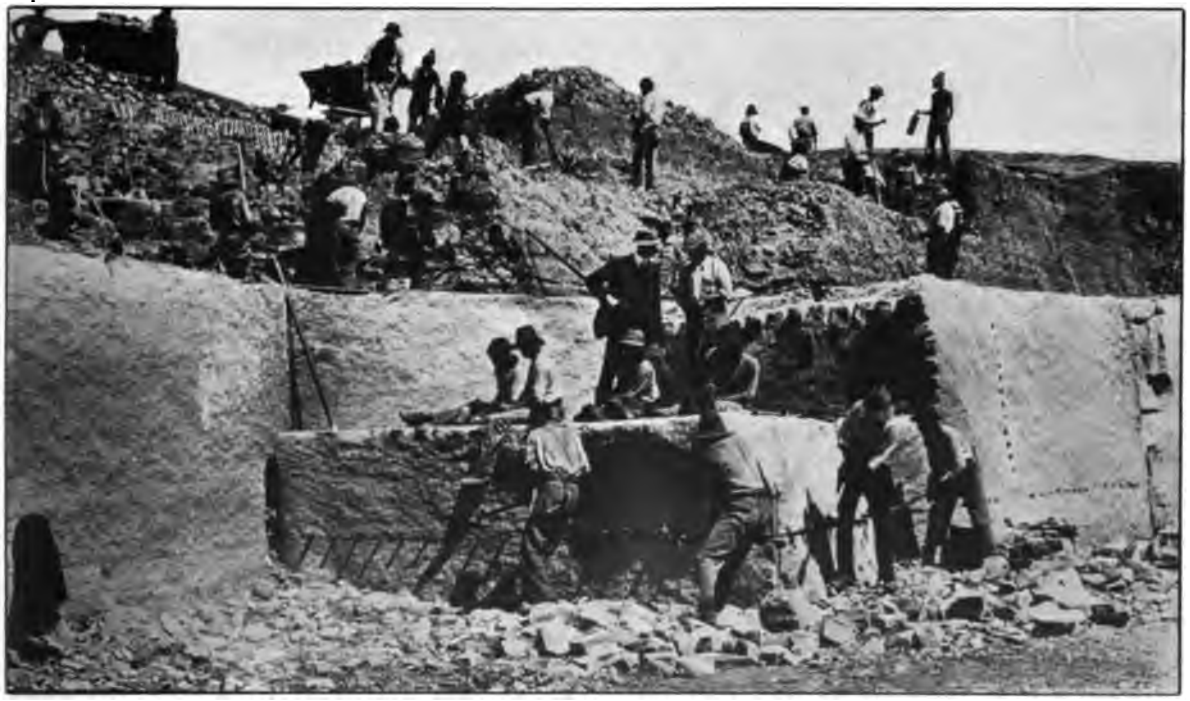

Fig. 2.– **A Portion of Steenpan Quarry,** near Coalbrook, Orange Free State.

Plate III.

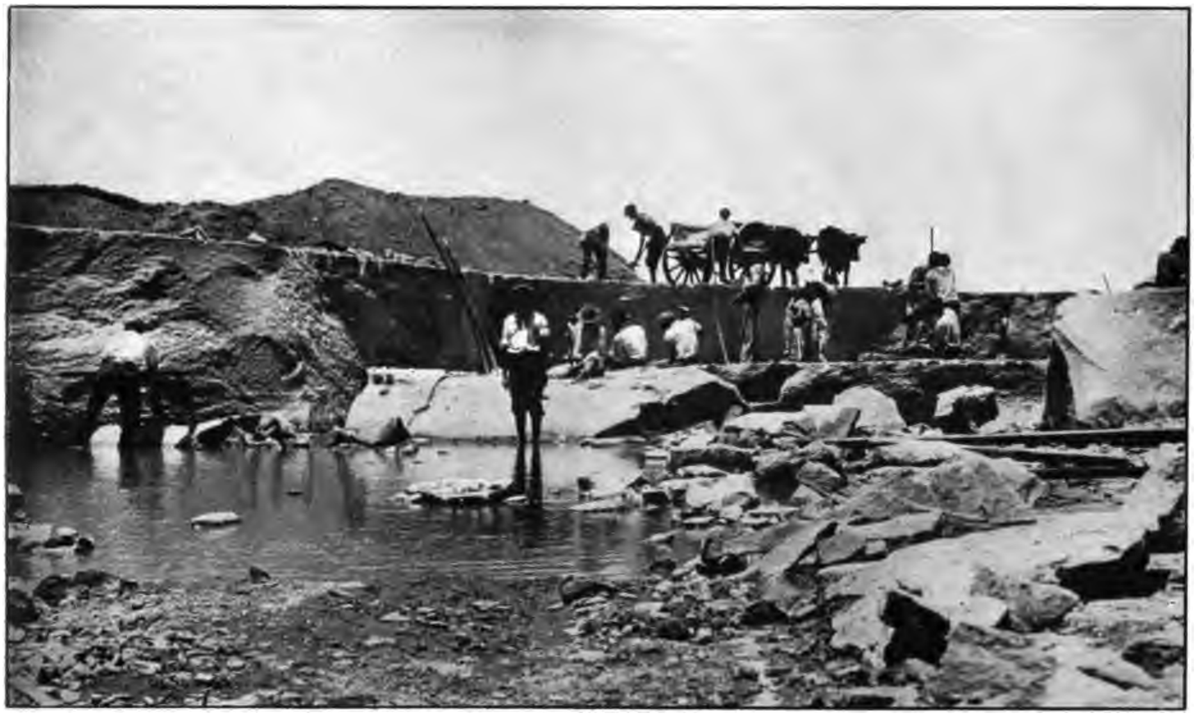

Fig. 1.—**A Portion of Flatpan Quarry,** near Coalbrook, Orange Free State.

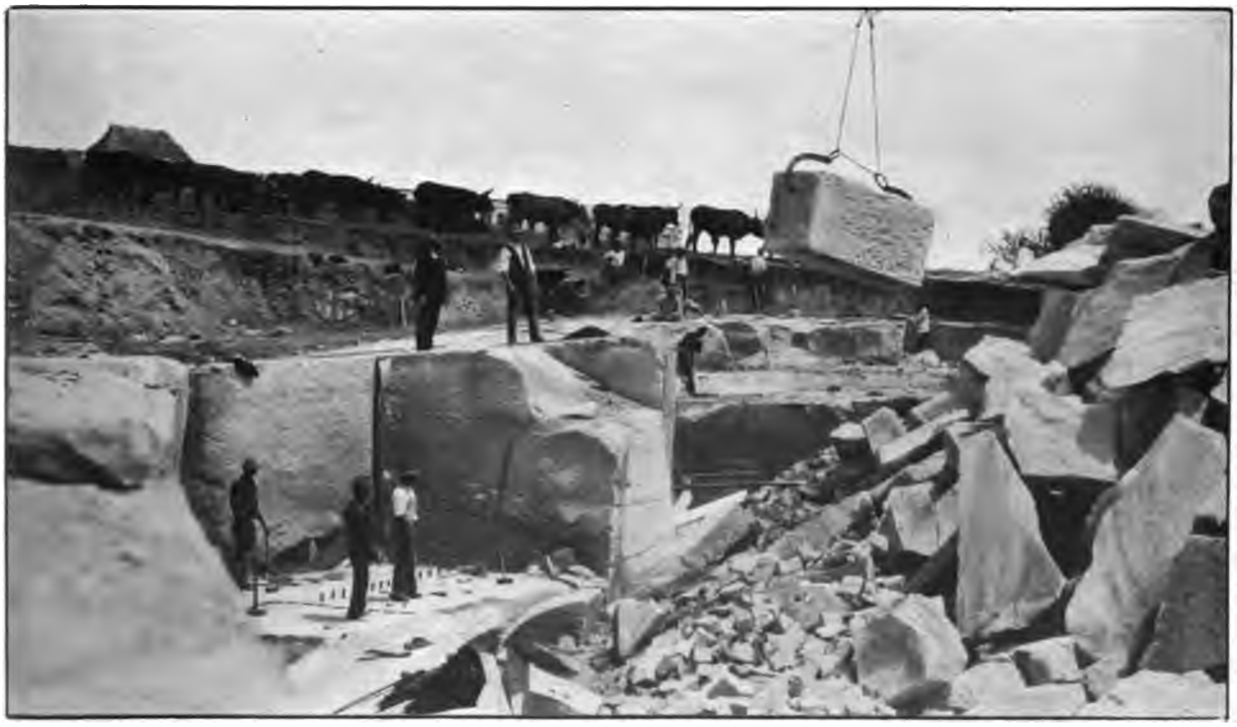

Fig. 2.—**Balmoral Stone Quarry,** Kromdraai, near Balmoral.

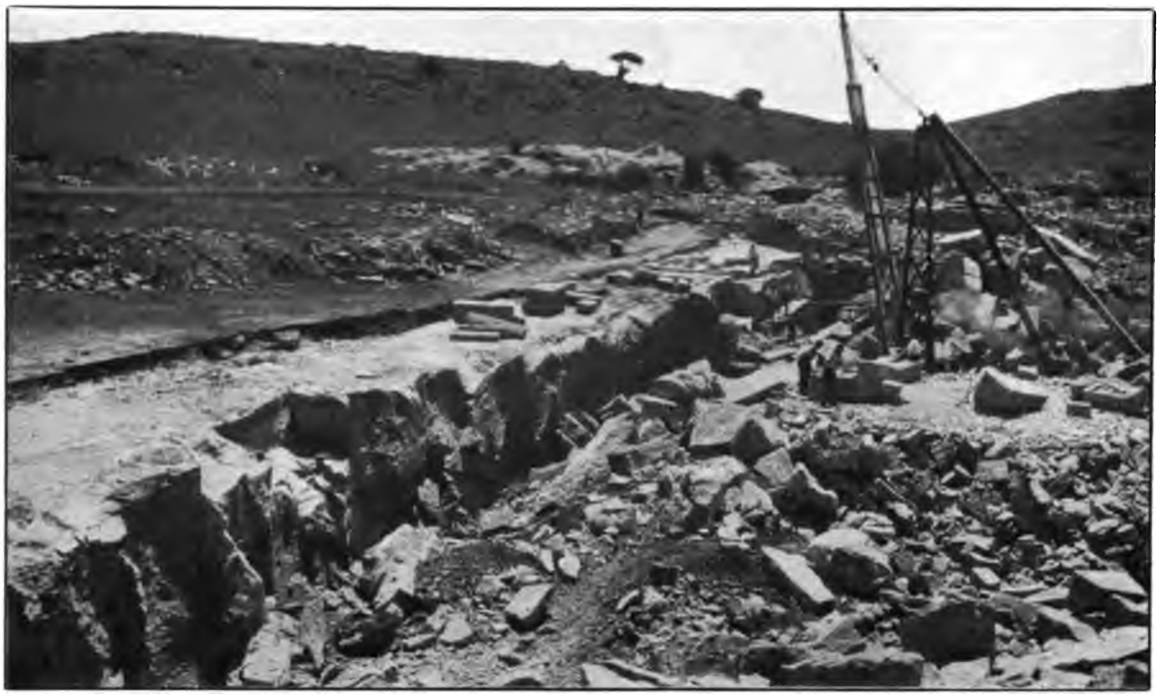

Fig. 1.—**Bayswater Stone Quarry,** Bloemfontein.

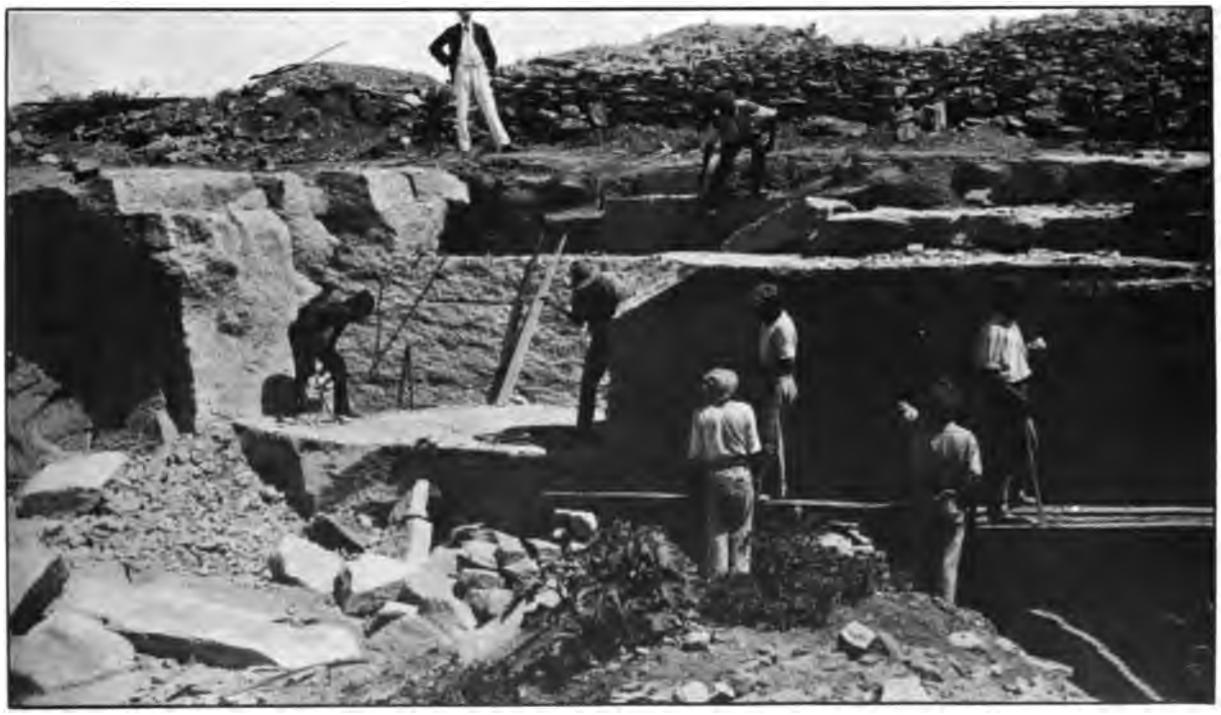

Fig. 2.—**A Portion of Bayswater Quarry,** Bloemfontein.

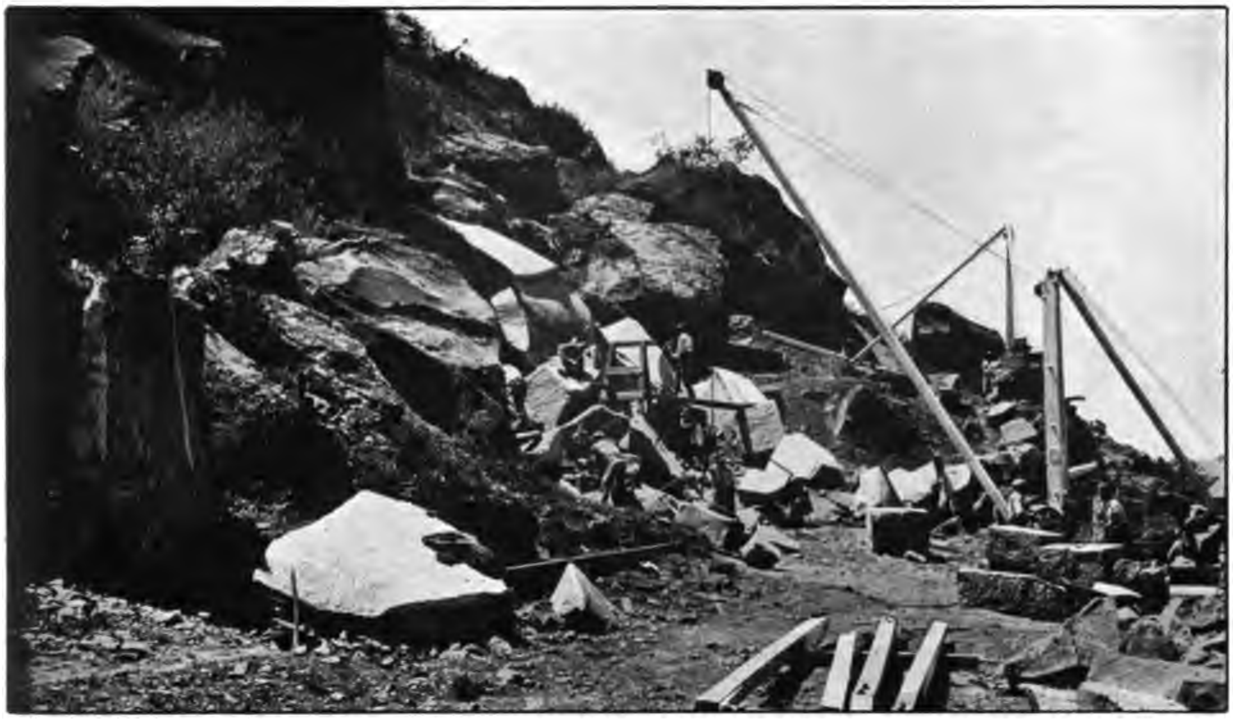

Fig. 1.—**Red Sandstone Quarry,** Buiskop, near Warmbaths.

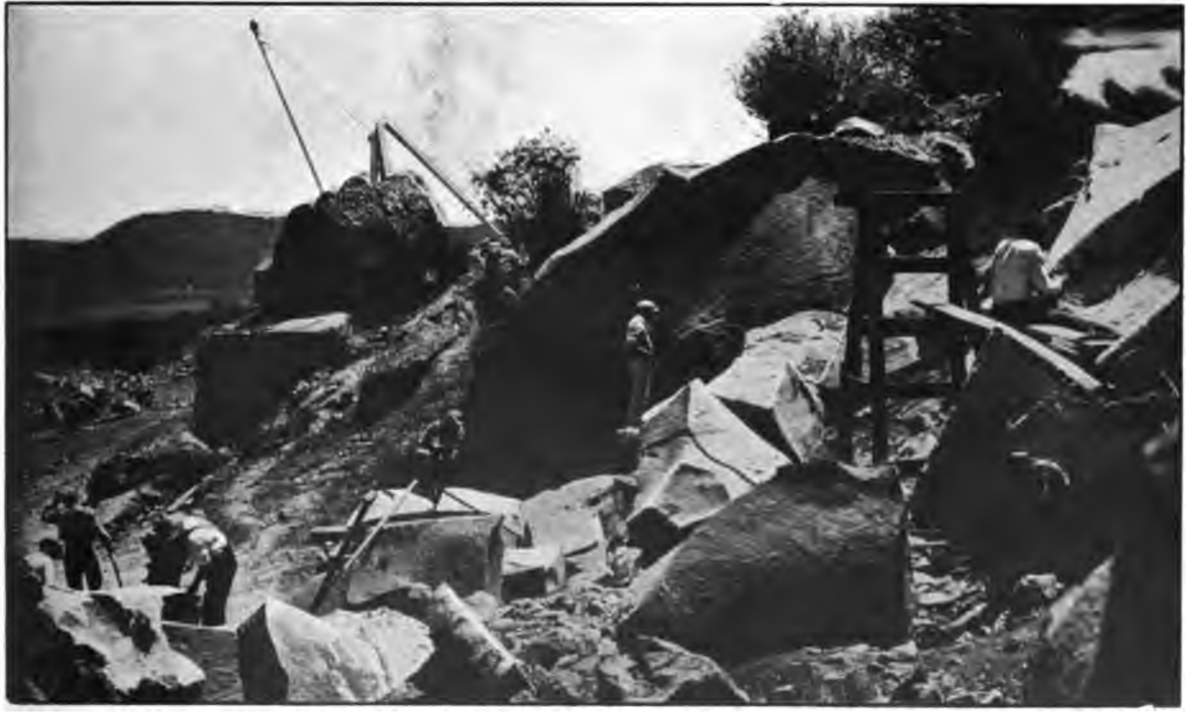

Fig. 2.—**A Portion of Buiskop Quarry,** near Warmbaths.

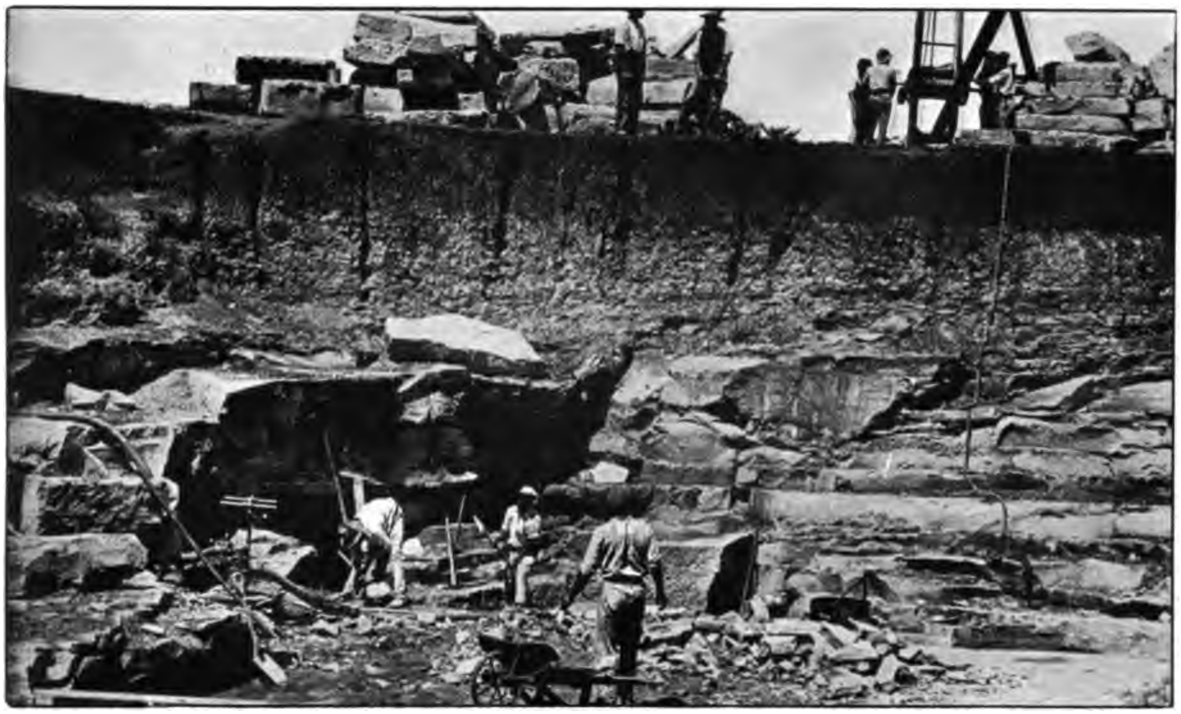

Fig. 1.—**Waterval Stone Quarry,** fourteen miles north of Pretoria.

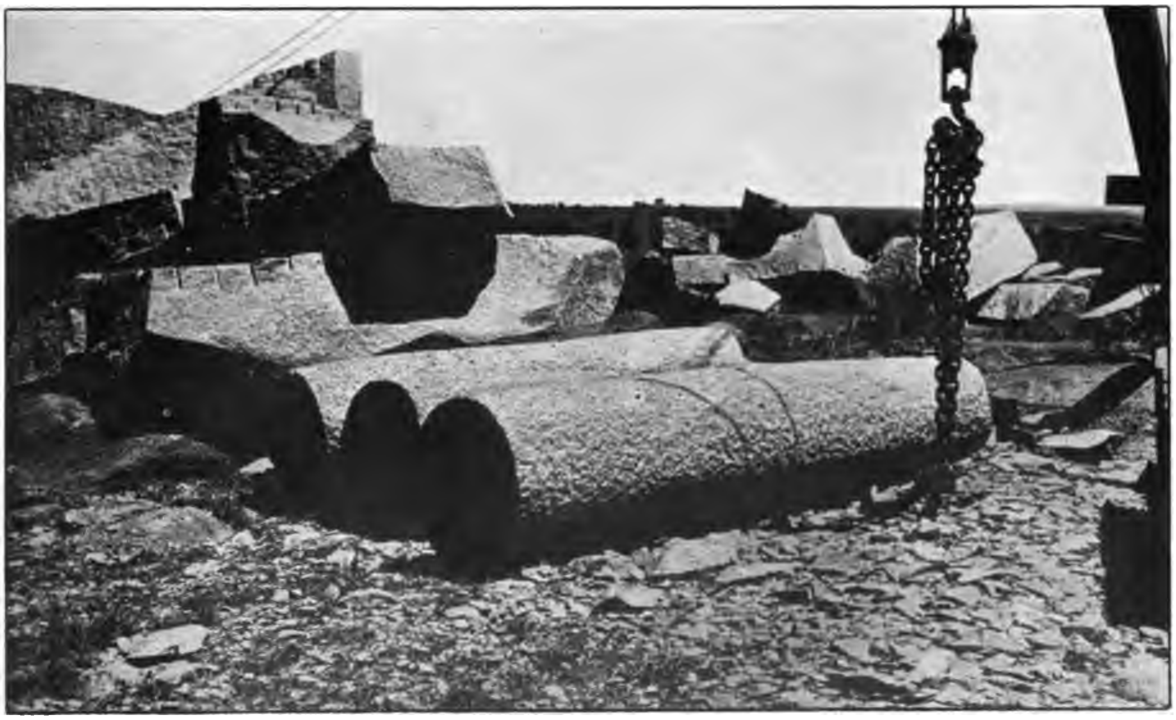

Fig. 2.—**Red Granite Columns,** quarried at Hamanskraal, north of Pretoria.

Plate VII.

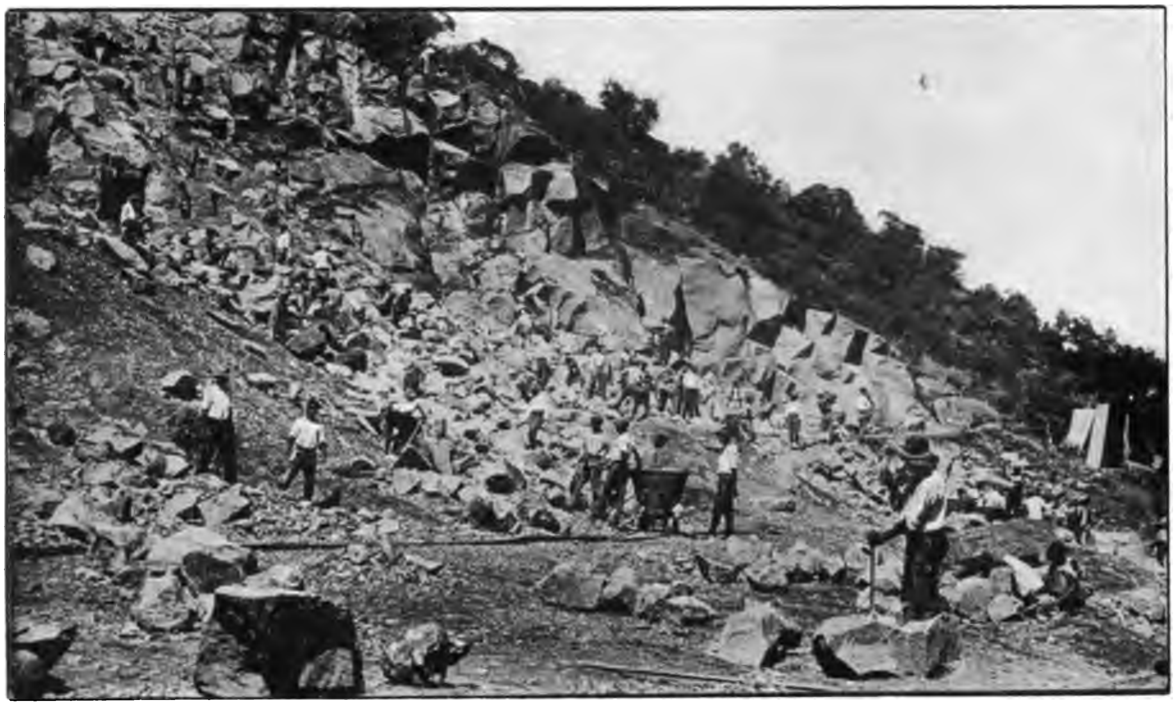

Fig. 1.—**Bon Accord Quarry (Norite),** ten miles north of Pretoria.

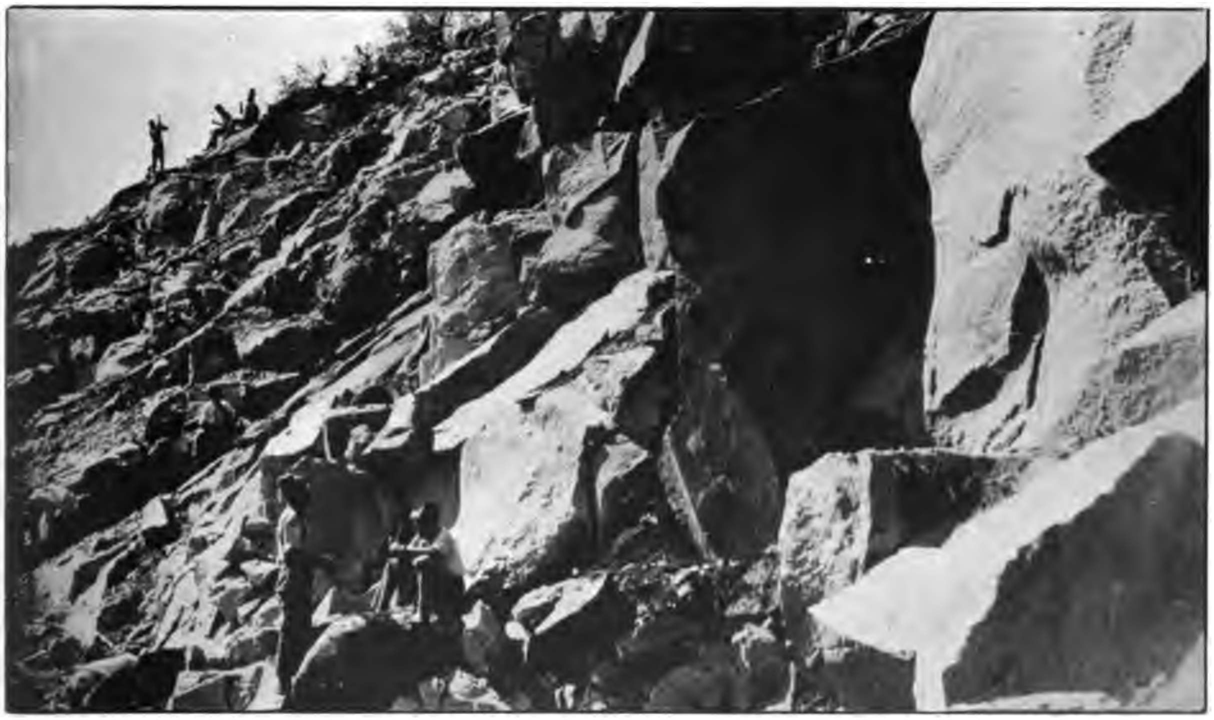

Fig. 2.—**A Portion of Bon Accord Quarry.**

II.

THE GEOLOGY OF A PORTION OF THE CENTRAL WITWATERSRAND

By E. T. MELLOR (*Geologist*)

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CONTENTS

I. INTRODUCTORY.—AREA SURVEYED.

II. PHYSICAL FEATURES.

III. GEOLOGY.

- (*a*) THE WITWATERSRAND SYSTEM (*Lower Division*).
  - *Nomenclature.*
  - *Beds below the Hospital Hill Quartzites.*
  - *The Hospital Hill Quartzites.*
  - *Beds above the Hospital Hill Quartzites.*
  - *Structural Features. Faulting in the Central Witwatersrand.*
  - *Occurrence of Older Granite at Rietfontein No.* 145.
  - *Conditions in the neighbourhood of Rietfontein No.* 145.
- (*b*) ROCKS LATER THAN THE WITWATERSRAND SYSTEM.
  - *The Langerman's Kop Beds.*
  - *Unconformable beds on the North side of Bezuidenhout Valley.*
  - *The Rietfontein Series.*
  - *Amygdaloidal Diabase of the Bezuidenhout Valley.*

II.—THE GEOLOGY OF A PORTION OF THE CENTRAL WITWATERSRAND.

By E. T. MELLOR (*Geologist*).

I. INTRODUCTORY.—AREA SURVEYED.

THE area mapped during 1910 was mainly confined to a strip of country lying north of the Main Reef Series and extending from the farm Witkopje No. 157 on the east to near the township of Maraisburg on the west, and occupied for the most part by the Lower Witwatersrand System. Its extent is approximately 120 square miles, involving 410 miles of geological boundary lines. Although this area, which centres about Johannesburg and is within easy reach of the town, has naturally attracted much attention from geologists and engineers for many years, and is included in various published maps,* its structure is far from being clear, and there are still many points of considerable importance about which much remains to be learnt, and which require careful comparison of the different portions of the Rand for their complete elucidation. The area is of the more importance, because being the most accessible and consequently the best known portion of the Rand, the sections shown by it are frequently used as a basis of comparison in dealing with the geology of other related localities.

One of the results of the present survey, however, has been to show that the area is one which presents a greater complexity of structure than is usually assumed to be the case, which among other results has brought about very great modification in the apparent succession and also in the apparent thicknesses of various members of the Lower Witwatersrand System. Not until the survey has been extended at least to the district further west will it be possible to deal completely with the present area, nor to draw any very reliable conclusions as to the extent and precise character of the modification which it has undergone, nor again to adopt a system of classification and mapping likely to be generally applicable over the Witwatersrand area or still more generally throughout the Witwatersrand System. For this reason it is proposed to confine the present report to giving some of the main points brought out by the survey as far as they can be at present interpreted and to leave the complete description of the area until it can be dealt with more comprehensively in connection with the extension of the work over a larger field.

II. PHYSICAL FEATURES.

The area here described lies at a very considerable elevation above sea-level averaging about 5700 feet and forming a portion of the watershed between the Vaal and the Limpopo Rivers.

The surface shows a moderate degree of relief of the general character of that usually found as a result of the denudation of an area of an inclined series of alternating shales and quartzites. Viewed broadly it may be said to consist a number, usually two or three, of roughly parallel east and west ridges with intervening valleys, corresponding respectively to the principal bands of quartzites and shales. The most persistent and characteristic ridge is that on the north formed by the Orange Grove Quartzites, which presents an almost continuous escarpment overlooking the lower ground occupied by the Older Granite and interrupted only by several small gaps corresponding in nearly all cases to small but well marked faults.

Eastwards this ridge, which may be conveniently referred to as the Orange Grove Ridge, terminates somewhat suddenly in the neighbourhood of Bedford Farm, some six miles north-west of the centre of Johannesburg, and suffers a considerable interruption at about the same distance to the north-north-west of the town on the farm Waterval No. 79. Westwards from the latter break a similar escarpment formed of the same quartzites is again a strong feature in the topography, but now takes a north-westerly course.

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* e.g.: Dr. Hatch's map of the Southern Transvaal, and the detailed map of the Bezuidenhout Valley accompanying a paper by Drs. Hatch and Corstorphine. Trans. Geol. Soc., S.A., Vol. VII, 1904.

Immediately west of the break on Waterval a northward projection of the ridge forms a conspicuous promontory jutting out into the flat for some two miles beyond the main line of the ridge. To the south of, and roughly parallel to the ridge just described, a second ridge formed in part by the Hospital Hill Quartzites, and which may be spoken of as the Hospital Hill or Observatory Ridge, is usually in evidence, separated from the first by valleys drained by lateral branches of the northward flowing streams. Eastwards this ridge, like the Orange Grove Ridge dies out somewhat rapidly, but at a point much nearer Johannesburg, while westwards it extends as a usually well marked feature beyond the limits of the area.

In some places, as for example in the suburbs north of the centre of Johannesburg, the two main ridges are connected by high ground, but elsewhere they are separated by valleys, the lowest portions of which lie some 300 to 400 feet below the summits of the ridges. From the more southerly ridge, formed by the Hospital Hill Quartzites or the slates below them, the ground usually falls by a moderate slope towards the neighbourhood of the Main Reef. In the eastern portion of Johannesburg, however, a third well-marked ridge occurs and is well developed in Kensington. This ridge rapidly dies out westwards, but in the opposite direction it continues to be a bold feature as far as the neighbourhood Rietfontein, some 8 miles to the east.

To the north of this escarpment and between it and the Orange Grove Ridge, extends a belt of low ground between one and two miles in width and largely occupied by amygdaloidal diabase and known as the Bezuidenhout Valley, the upper part of which is divided into two branches by the eastern portion of the Hospital Hill or Observatory Ridge. Into the head of the more southerly of these two branches projects the conspicuous hill known as Langerman's Kop.

The area is drained by numerous small streams forming the extreme head waters of the Vaal and Limpopo. Of these the latter mostly rise between the two main quartzite ridges and passing by comparatively narrow poorts or gaps in the escarpment of the Orange Grove Quartzites flow northward into the lower ground occupied by the Granite.

More open courses to the granite area are followed by the spruits draining respectively the Bezuidenhout Valley and Waterval No. 79, the former passing round the termination of the Orange Grove Ridge, and the latter through the wide gap already referred to.

The tributaries of the Vaal, mainly rising south of the Hospital Hill ridge or its continuation, flow southwards by less pronounced valleys, of which that of Natal Spruit on the eastern side of Johannesburg and of the stream rising near Fordsburg on the west are examples.

The topography of the area shows a very close relationship to its geological structure, and has in turn largely influenced the laying out of the town of Johannesburg and its many suburbs.

III. GEOLOGY.

While in the area under review the number of formations represented is comparatively few, on the other hand the relationships between these formations as well as the succession and thicknesses of the rocks of which they are composed offer very considerable difficulties, the evidence being in many cases too fragmentary to form a reliable basis for deduction, and it is most probable that a satisfactory solution of these questions can only be found by careful comparison with other areas in which these rocks occur, when a sufficiently detailed survey of these shall have been made.

The sedimentary rocks belong for the most part to the Witwatersrand System and more particularly to its lower division. There are in addition several more or less isolated occurrences of sedimentary rocks which in some cases are certainly unconformable to the Witwatersrand System, and in others most probably so. To the latter category belong the beds occurring in Langerman's Kop and the well-known Rietfontein Series, occurring respectively towards the western and eastern extremities of the Bezuidenhout Valley, while to the former belong certain less known beds which overlie the Lower Witwatersrand System on the northern side of the same valley. In addition to the sedimentary formations, the rocks of the district include the "Older Granite", upon which the Witwatersrand System rests and the amygdaloidal diabase which occupies the greater portion of the Bezuidenhout Valley and which is almost certainly a part of, and identical with, the similar diabase still more extensively represented to the south in the Klipriviersberg Amygdaloid, and which is of later date than all the other formations above mentioned.

As these rocks are for the most part well-known and have been already described by various writers in previous survey reports, only those points will be dealt with in the present account in which the results of the survey appear to afford additional information with respect to the formations concerned.

(*a*) *The Witwatersrand System* (*Lower Division*).

This division of the Witwatersrand formation is usually taken to include all the beds occurring between the granite at the base of the system and the Main Reef Series. Most of the descriptions which have been given of this formation, including those of Draper, Molengraaff and Hatch and Corstorphine have been largely based upon observations made in the area under review, where some of the best known and most frequently visited sections occur. While, however, the Central Witwatersrand area probably offers fairly true sections of a portion of the Lower Witwatersrand System, the survey results so far obtained point to the conclusion that the sections presented in this neighbourhood, especially as concerns the beds between the Hospital Hill Slates and the Main Reef Series, have been so seriously affected by faulting of a very severe and widespread character as to render them far from representative of normal conditions. The evidence upon which this conclusion is based will be given later in connection with the description of the local structural features.

Nomenclature.

Of the numerous previously published descriptions of the Witwatersrand System, the latest summary has been given by Drs. Hatch and Corstorphine* and a definite nomenclature proposed for the various subdivisions of the System. This nomenclature will be followed as far as practicable in the present description, more especially with reference to that portion of the System between the base and the Hospital Hill Quartzites. With regard, however, to the Hospital Hill Quartzites and the beds between these and the Main Reef Series, some confusion appears to exist. For example, it is clear from the descriptions and sections of the Observatory Ridge given by the authors referred to,† that it is intended to apply the term Hospital Hill Quartzite to the quartzites appearing in Hospital Hill and the Observatory Ridge; on the other hand with reference to the Kensington Ridge,‡ the name is made to include quartzites of the Hospital Hill Series together with some hundreds of feet of quartzites of a different character whose position is higher in the System, and which are well known further west, in part at least, under the name of the Government Reef Series. This latter term is in such general use among local engineers and geologists, and the series to which it is applied is so well known and so extensively represented, that it can scarcely be omitted from any system of nomenclature. In the present description this term is used to indicate the extensive series of usually coarse quartzites and grits with small pebble beds, alternating with hard red and sometimes very ferruginous shales which succeed the Hospital Hill Quartzites, while the latter term is applied to the quartzites of Hospital Hill proper, together with at least two other thick bands of similar quartzite which normally succeed them, but which are not visibly represented on Hospital Hill or the Observatory Ridge.

Beds below the Hospital Hill Quartzites.

That portion of the Lower Witwatersrand System which lies below the Hospital Hill Quartzite is very well exposed over a distance of over 20 miles extending from the farm Witkopje No. 151 on the east to the township of Maraisburg on the west. From the regularity and persistency of the outcrops, the section here presented, which has been fully described by various authors, may probably be accepted as fairly representative of the normal succession of the beds of this portion of the Witwatersrand System in the Central Rand.

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* Geology of South Africa.

† Hatch and Corstorphine, Geology of the Bezuidenhout Valley, Trans. Geol. Soc., S.A., Vol. VII, 1904, p. 100.

‡ Hatch and Corstorphine, Geology of the Bezuidenhout Valley, Trans. Geol. Soc., S.A. Vol. VII, 1904, p. 102.

In that portion of the system lying along the Hospital Hill Slates, however, the determination of the full succession is a much more difficult matter, and it cannot be said that either upon this point or upon the nomenclature to be applied there is as yet general agreement.

The Hospital Hill Quartzites.

Reference to the various descriptions which have been given of the formation, and a comparison of these with the sections which accompany them, or with those actually seen on the ground show that no very precise meaning has been attached to the term Hospital Hill Quartzite, although the rocks to which it is applied are among the best known on the Rand, and the term itself has long been in common use in local geology. As represented in Hospital Hill, the locality from which the beds take their name, these quartzites consist of a single series of beds unbroken by anything of a shaly nature. The quartzites have very well marked characters by which they can be recognized with moderate certainty by any one well acquainted with local geology. Among the most constant of these characters are a moderately fine texture with occasional coarser bands showing well-rounded clear grains in a finer matrix (known locally as sago structure) and a bright green colouration frequently shown both by joint surfaces and in the body of the rock. Both this colouration and the " sago " structure are however occasionally seen at other horizons in the Witwatersrand System.

Although the quartzite which occurs in Hospital Hill forms one of the most prominent surface features in the town of Johannesburg, rising into a bold rocky ridge continued eastwards into that upon which the Observatory stands it is very difficult anywhere near the town itself to obtain any information as to what lies above.

In the neighbourhood of the Observatory, the dip slope of the big quartzite is clearly overlain by the amygdaloidal diabase of the Bezuidenhout Valley, but from Judith Paarl westwards to Brixton the quartzite dips under a deep covering of red soil which effectually hides the succeeding beds. About the western portion of Brixton, however, the quartzite of Hospital Hill is clearly seen to be succeeded by at least two other quartzites of very similar character, in both of which the sago structure and green colouration is frequently as well marked as in the main quartzite itself. These quartzites are separated from each other and from the main quartzite by broad belts of highly ferruginous shales very similar in character to those underlying the quartzite of Hospital Hill, and a similar succession is to be met with in most unbroken sections west of this point. It therefore appears that the quartzite represented in Hospital Hill is only one of a series of at least three similar bands alternating with highly ferruginous shales. It may be noted that the thickness of the lowest of the three bands of quartzites corresponds very closely with the thic ness shown by the quartzite of Hospital Hill and the Observatory Ridge of which this particular quartzite is a continuation.

Beds above the Hospital Hill Quartzites.

Probably the portion of the Witwatersrand System which in this area departs most from the normal conditions is that between the Hospital Hill Quartzites and the Main Reef Series. It is well known that as compared with the country further west, sections in the central Rand show a considerable diminution in thickness, and this difference has been universally attributed to a thinning of the series from west to east as a result of the original conditions of sedimentation. Another explanation however might be given, and one which appears to agree more closely with the conditions to be observed, viz., that the apparent diminution in thickness on the Central as compared with the West Rand is due to the effects of the severe faulting to which the area has certainly been subjected, resulting in the elimination of considerable thickness of beds from the sequence as exposed at the surface. That faulting of this character, resulting in such an elimination of beds from the section presented at the surface, has taken place, can be very clearly demonstrated in various localities, as for example to the north of Maraisburg where the outcrop of the Hospital Hill Quartzites is brought very close to that of the Orange Grove Quartzites, and again similarly to the north of Florida. In these cases the greater part of the shales between the Hospital Hill Quartzite and the Orange Grove Quartzite, some thousands of feet in thickness, have been eliminated from the section. In the neighbourhood of the town of Johannesburg it is the beds above the Hospital Hill Series which have been most affected by the faulting referred to. Generally speaking, it is the shales which suffer such elimination with the result that quartzites normally separated by considerable thicknesses of shale come to be very close to one another. The elimination of the shales in this manner can be well seen in many localities, as for example in the Kensington ridge to the south of Malvern.

In the Kensington ridge the thickness of beds represented between the Hospital Hill Quartzites and the horizon of the Government Reef is very much less than at Brixton and this again less than that represented still further west. These discrepancies, as already stated, appear to be more reasonably attributed to the effects of faulting than to any rapid diminution in the thickness of the beds originally laid down, for whereas there is little evidence of the rapid thinning of any particular series or beds, there is abundant and striking evidence of the occurrence of faulting of the kind referred to a degree fully sufficient to account for the results observed. With the extension of the survey further west, it will probably be possible to give a more or less complete section of the beds between the Hospital Hill Quartzites and the Main Reef Series and to determine with more certainty than is at present possible, the manner and extent of the modification which the central section has undergone.

Structural Features.—Faulting on the Central Rand.

Perhaps the most striking result of the present survey is the evidence afforded by detailed mapping of the extent to which this area has been affected by faulting on a large scale, the results of which have a most important bearing on the interpretation of the sections presented by the Central Rand, hitherto generally regarded as typical and representing normal sections of the Witwatersrand formation in this area. Although the existence of faulting has been previously noted locally at several points,* neither its extent nor its true significance has yet been adequately recognized. This is probably due to the fact that the faulting is for the most part coincident or nearly so with the strike of the formation and consequently difficult to detect unless detailed mapping over a considerable area is undertaken. The present survey shows that the Lower Witwatersrand beds are traversed by a strongly marked line or zone of strike faulting which has greatly modified the apparent thickness and succession of the Lower Witwatersrand beds throughout the area. Many of the difficulties in reconciling the various sections presented in this locality, both with one another and with those from adjacent districts are to be attributed to the faulting referred to, and it is also very probable that the section presented by the neighbourhood of Johannesburg, usually regarded as one of the standard sections of the Witwatersrand System has been so much modified as to render it far from representative of normal conditions even within the Central Rand.

As might naturally be expected in faulting of this type the resulting break is far from being always sharply defined, for while in many cases the line of faulting can be located very closely, in others the break consists rather of a faulted zone or of several more or less parallel faults, probably associated with branch faults making acute angles with the main line and passing obliquely across the strata affected.

The general course of the line or zone of maximum faulting, from east to west passes across the middle of the farm Rietfontein No. 145, the southern portion of Elandsfontein No. 147, and by the townships of Kensington, Troyeville, and the middle of Johannesburg to near the southern extremity of Brixton; thence across the middle of the small farm Middlefontein No. 128 to pass just north of the township of Maraisburg and continues in a north-westerly direction beyond the limits of the present survey.

The course of the faulted zone is everywhere marked by a pronounced contrast in the degree of dip shown by the beds on opposite sides of it. The dips of the beds to the south of the line are without exception extremely high, being usually vertical or even slightly overtilted; while on the north side of the fault-zone very much lower dips prevail ranging from 25 degrees to 60 degrees with an average of about 40 degrees, except in the neighbourhood of Brixton and Auckland Park when the dip of the quartzites of the Hospital Hill Series changes somewhat suddenly from 50 degrees to 80 degrees and maintains a fairly high dip averaging about 65 degrees as far as the western end of Claremont township. This partial exception to the prevailing low dips to the north of the break may however be due to a local subsidiary fault.

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* W. Gibson: The Geology of the Gold-bearing and Associated Rocks of the Southern Transvaal, Quart. Journal Geol. Soc., Vol. XLVII, pp. 404–435, London, 1892; also D. Draper, Section in the Geological Society's Museum, Johannesburg; G. A. F. Molengraaff, "Geology of the Transvaal", Eng. Translation, 1904, p. 11.

It is interesting to note that it is along the line of faulting defined above that nearly all the most difficult points in local geology arise, including the much-debated and still unsettled question of the beds occurring at Langerman's Kop and in the neighbourhood of the Rietfontein Mines. That the fault is of sufficient magnitude to have an important bearing on the structure of the district is shown by the fact that it has already been followed continuously over a distance along the strike of over 20 miles, over which distance there is no section of the Witwatersrand System which is not greatly affected by it, while in the neighbourhood of Rietfontein one of its effects is to bring the Hospital Hill Quartzites, normally separated from the Older Granite by some thousands of feet of Lower Witwatersrand beds, into contact with that rock.

Mention has already been made of the fact that the effects of the faulting are not confined to a well defined line but are shown over a narrow zone of varying width, involving in some cases the existence of two or more parallel faults. Further, the conditions presented at various localities do not appear capable of explanation as the results of any simple fracture. They appear rather to be the result of somewhat complicated folding movements, the main break being such as to bring the limits of two different folds into contact with one another. The Witwatersrand beds on the Rand are generally regarded as representing a continuous section and as forming part of a single synclinal fold embracing the greater part of the Rand area, the beds being duplicated to the east of Johannesburg by an oblique fault, known as the Bezuidenhout Valley Fault. While, however, a synclinal arrangement is shown by the formation over a very large portion of the area, a consideration of the dips shown by the beds along its northern margin and forming a broad belt to the south of the main mass of the Older Granite shows that these beds on the contrary form part of an anticlinal fold, which is separated on the south from the main syncline throughout the whole area under consideration by the line of faulting described above. The folding and subsequent faulting of the strata was subsequent to a great extent at least to the extrusion of the Klipriversberg Amygdaloid, which in the Bezuidenhout Valley has partaken in the folding process and has been greatly affected by the compression and shearing which accompanied these movements.

The sudden change in dip which is seen in passing from the north to the south side of the fault zone is perhaps nowhere more plainly shown than in one of the best known and perhaps most widely studied sections of the Central Rand, namely, that seen just east of Johannesburg between Orange Grove and the Henry Nourse Mine, passing through the Observatory and Langerman's Kop. While the sudden change of dip observable on this line just south of Langerman's Kop has been generally taken as indicating the occurrence of a considerable fault in this locality, the extent and significance of the break appears to have escaped the notice of most observers, probably owing to the fact that for some miles east of Langerman's Kop the structure of the country is very much obscured by the presence of the amygdaloidal diabase, while to the west similar difficulties arise from the presence of the town, and especially also of a belt of deep red surface soil which almost entirely obscures the underlying rocks over a large area. Gibson* in an early description of the geology of this area appears to have recognized the extension of the fault to the east and west, as also the existence of folds affecting the Witwatersrand beds; his interpretation, however, of the effects of these folds on the succession of the beds has not been confirmed by the observations of subsequent observers. The duplication of a portion of the Lower Witwatersrand System shown in the Bezuidenhout Valley has been ascribed by Drs. Hatch and Corstorphine,† who do not recognize the fault to the south of Langerman's Kop, to an oblique fault crossing the Bezuidenhout Valley from near Jeppestown Station to the termination of the Orange

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* W. Gibson, *loc. cit.*

† Hatch and Corstorphine, Geology of the Bezuidenhout Valley, Trans. Geol. Soc. of S.A., Vol. VII, 1904.

Grove ridge near Bedford farm, the fault being prior to the laying down of the Langerman's Kop beds and the amygdaloidal diabase of the valley. Although such a fault would explain many of the structural features of the valley, no direct evidence of its existence has been met with ; on the other hand, the conditions are equally well explained as a result of the east and west faulting described above, and the amygdaloid has certainly partaken to a great extent in the movements which have affected the other local rocks.

Occurrence of Older Granite on Rietfontein No. 145.

In the course of the survey a hitherto unnoticed occurrence of the Older Granite was found at the base of the Hospital Hill Quartzites which form part of the ridge which bounds the Bezuidenhout Valley on the south. This occurrence of granite in contact with the Hospital Hill Quartzites drew attention to the magnitude of the disturbance which has taken place in this locality along the line of faulting referred to, and the evidence it afforded has been fully confirmed by the conditions found to obtain in the country further east.

The granite is best seen outcropping just east of the main road which descends from the quartzite ridges on to Barrett's Rietfontein, a short distance to the east of the common boundary of Rietfontein No. 145 and Elandsfontein No. 147. Here the rock forms fairly conspicuous outcrops near the foot of the quartzites. Owing to the sheared condition of the granite, its outcrops bear considerable resemblance to those of the quartzites in the vicinity, a resemblance which has probably been the reason of its having hitherto escaped observation. Those portions of the granite, however, which have not been affected by shearing show unmistakably the character of the rock. Although outcrops of the granite are confined to the east of the road, there is good evidence of its extension for a considerable distance westwards. Old prospecting pits on the eastern boundary of Elandsfontein No. 147 show decomposed granite, and a trench much further west at the foot of the ridge below the Trigonometrical Survey beacon is in the same rock. To the east the granite has been met with in several of the prospecting works near the eastern boundary of Rietfontein No. 145 and has been encountered in the mine workings, the dump at the old No. 1 shaft near the eastern end of the workings consisting almost entirely of granite.

Conditions in the Neighbourhood of Rietfontein.

The neighbourhood of Rietfontein No. 145 presents somewhat remarkable structural features which can only be understood by reference to a more extended area than that in the immediate neighbourhood of the Rietfontein Series. In order to follow the conditions here presented, it is necessary to begin somewhat further east on the farm Witkopje No. 157, about one mile east of Rietfontein. Here a practically complete and normal section of the Lower Witwatersrand beds from the Orange Grove Quartzites to the Hospital Hill Quartzites can be seen. A complete section of the Orange Grove Quartzites agreeing closely with that shown at Orange Grove itself is to be found in the low but conspicuous kopje lying about one and a half miles east of Rietfontein Mine. On the western slopes of the kopje, the Water Tower Slates crop out, while to the south characteristic outcrops of the Contorted Bed and the Green Quartzite of the Hospital Hill Series are well seen, the latter lying near the southern boundary of the farm. A broken outcrop of the well-known " Speckled Bed " is seen about the middle of the northern margin of the big Witkopje pan. From the kopje eastwards the outcrop of the beds is very regular and easily followed across Witkopje; westwards, however, towards Rietfontein the outcrops are not so continuous nor so easy of recognition. A short distance west of the kopje there is a transverse fault passing north and south through Witkopje pan, beyond which all the beds are much broken, their outcrops becoming more difficult to follow across Rietfontein, so that any one confining his observations to that farm alone, would probably find great difficulty in realizing the conditions there presented, which will be best understood by reference to the Map, plate x.

Little difficulty is found in following the continuation of the Hospital Hill Quartzites and the Contorted Bed, both of which can be traced without difficulty on to Barrett's Rietfontein, the former continuing thence with the exception of certain breaks shown on the map to the ridge lying to the south of Langerman's Kop, while the Contorted Bed is also represented at intervals just north of the same line.

The continuation of the Orange Grove Quartzites westwards from Witkopje is, however, not so easily followed, and it is only by careful plotting of the outcrops of this and the more easily followed beds already mentioned that their relationships to one another and to the Rietfontein Series can be made clear. West of the transverse fault referred to, the Orange Grove Quartzites become very much broken, but can be followed with little difficulty to the railway, beyond which they crop out again about the south-east margin of the big grass-pan on the eastern boundary of Rietfontein. The general direction of the strike of the quartzites up to this point would indicate their probable continuation either beneath or to the north of the outcrop of the Rietfontein Series and one or other of these views appears to have been universally taken. The location of the Rietfontein Series according to the latter view within the assumed course of the Orange Grove Quartzites, and its consequent inclusion as a member of the Lower Witwatersrand System has led to extensive prospecting for the Rietfontein Series at corresponding horizons in other localities. There is, however, good evidence that the course of the Orange Grove Quartzites is considerably different from that above indicated. Just east of the Witkopje boundary the quartzites turn to the south-east and follow the course indicated on the map, along which line outcrops of quartzite indistinguishable in character from the more westerly outcrops on Witkopje, occur at frequent intervals as far as the eastern boundary of Barrett's Rietfontein. Near the Witkopje boundary these Rietfontein outcrops, known locally as the " cherty quartzite " occasionally show a continuous section fifty yards in width, the dip as far as determinable being vertical, so that a very considerable thickness of quartzite is represented, although the outcrops in many places might suggest a much smaller body.

Further west, while the character of the quartzite is closely maintained, the outcrops are not so wide, although perhaps more conspicuous. They are, however, sufficiently continuous to leave little doubt as to their continuity and their identity with the Orange Grove Quartzites.

For a considerable distance over Rietfontein a highly ferruginous shale, closely similar to the Water Tower Slates of the sections nearer Johannesburg and on Witkopje crops out at frequent intervals to the south of the quartzites, south of which again a smaller quartzite which probably represents the Ripple Marked Quartzite, maintains a parallel course. Between this and the Hospital Hill Quartzites on the New Rietfontein Estates, the " Speckled Bed " and " Contorted Bed " are typically represented.

At the Kopje above mentioned on the farm Witkopje where the complete section of the Orange Grove Quartzites is to be seen, prospecting trenches at the base of the quartzites yield good evidence of the presence of the Older Granite at that horizon, and although no outcrops of this rock occur on Rietfontein there is abundant evidence from prospecting and mine workings of its presence between the Rietfontein Series and the Witwatersrand beds as shown on the map. It will be seen that in passing westwards from Witkopje across Rietfontein, the width of outcrop of the beds between the Orange Grove and Hospital Hill Quartzites shows a continuous decrease with a tendency for the Hospital Hill Quartzites to approach more closely to that of the Orange Grove Quartzites and consequently also to that of the Granite, which results a little further west on Barrett's Rietfontein practically in actual contact of the two. The result is such as, in plan, to suggest a thrust of the more southerly beds over the more northerly.

It is difficult, however, to reconcile the prevailing dips with this explanation, and it seems more probable that the compression the outcrop of the Lower Witwatersrand beds and the bringing into contact of the Granite with the Hospital Hill Quartzites is the result of the forcing of the Granite over the edges of the beds in a broken fold of the sedimentary rocks. Proceeding westwards the amygdaloidal diabase similarly encroaches on the upturned edges of the Lower Witwatersrand strata, so that in the neighbourhood of the Geldenhuis mill, the Hospital Hill Quartzites cease to form a visible part of the quartzite ridge which thus comes to be composed entirely of beds lying above the horizon of the Hospital Hill Series. About half a mile west of the Geldenhuis mill the Hospital Hill Quartzites are again in evidence, to be again eliminated from the surface section a little beyond the monument on the Kensington Ridge.

Many striking instances of the effects of the faulting along the line indicated are shown by the ridge which bounds the Bezuidenhout Valley on the south. The elimination of the

Hospital Hill Quartzites over a distance of approximately two miles near the Geldenhuis mill has just been referred to. A common effect which can be observed at many points, is the rapid narrowing or even disappearance of the bands of shales which normally separate the numerous quartzites which lie above the Hospital Hill Series. In one example, one of these shale bands with an approximately vertical dip can be seen to diminish in width of outcrop from 300 to 100 feet within a distance along the strike of 200 yards, and it seems probable that one at least of the causes of the discrepancies between the thicknesses of the various beds in the Central as compared to the West Rand is due to similar compression or elimination of various members of the succession, particularly the shale bands.

About one and a half miles east of the Geldenhuis mill, near the Trigonometrical Survey beacon, the Hospital Hill Quartzites and the quartzites of the overlying Government Reef Series are much broken and a faulted portion of the ridge projects some distance beyond the main line of escarpment into the flat. One mile east of the mill the Hospital Hill Quartzites, followed in turn by several quartzites of the series above them, cease to crop out on the surface or to take part in the formation of the ridge, their outcrops merging into the flat occupied by the amygdaloidal diabase, whose outcrops here approach very closely to the foot of the quartzite ridge. Over a distance of nearly two miles the Hospital Hill Quartzites and the lower quartzites of the series above, are absent from the ridge, although they usually form the most conspicuous part of it, and it is only about three quarters of a mile west of the mill that the ridge again shows the normal sequence, with the Hospital Hill Quartzites forming the escarpment overlooking the Bezuidenhout Valley. The area west of the Geldenhuis mill is an extremely broken one, and the extent of the movements which have taken place is shown by the occurrence over some distance of outcrops of the Contorted Bed immediately to the north of one of the quartzites of the Government Reef Series, distinguishable by the presence in it of the numerous bands of coarse grit and small pebbles, so characteristic of this series, the Hospital Hill Quartzites which should normally lie above the Contorted Bed being absent.

It will thus be seen how widely a section of the Kensington ridge at this point would differ from sections taken elsewhere. For over a mile westwards as far as the Scottish Monument, the ridge shows more nearly the normal succession, but just west of the monument the whole series of quartzites is displaced to the northward by an oblique fault as shown, west of which the Hospital Hill Quartzites are again missing from the section, so that the Contorted Bed here again lies immediately north of the quartzites of the Government Reef Series to the north of which again come the beds of Langerman's Kop.

A very common feature of the zone of faulting is the frequent elimination of beds for considerable distances along the strike. In this way the Hospital Hill Quartzites and other members of the Lower Witwatersrand System are frequently absent from sections taken across the line of faulting, a condition which has apparently hitherto escaped notice and has probably been one of the most fruitful sources of disagreement as to the normal succession of the beds.

A section for example passing near the Scottish Monument would differ materially from one taken only a short distance to the west through the Sanatorium, or to the east near the Geldenhuis mill, since in both these latter an important member like the Hospital Hill Quartzite is absent. In such detailed maps of the district as have been published, for example that accompanying a paper by Drs. Hatch and Corstorphine, the local absence of the Hospital Hill Quartzites is unnoticed and thus no distinction is made between these beds and those of a higher horizon belonging to the Government Reef Series which take part in the formation of the same ridge. In the Kensington ridge the Hospital Hill Quartzites cease to be in evidence west of the oblique fault near the Scottish Monument, the continuation of the ridge consisting of quartzites of the Government Reef Series, which beds pass near Jeppes Station and across the middle of Johannesburg to appear again conspicuously west of the town, to the north of Langlaagte, whence they may be easily followed westwards beyond the limits of the present area.

Owing to the ground being so closely built over, it is now very difficult to trace the exact course of the main line of faulting through the town of Johannesburg. From Langlaagte onwards, however, it is easily followed, continuing for a long distance in this direction in the Government Reef Series and nearly parallel to the strike, passing to the north of Maraisburg across the Hospital Hill Quartzites into the beds below. The tendency of the faulting to eliminate portions of the normal section and diminish the width of outcrop is well shown in the same locality where the Hospital Hill Quartzites approach very closely the quartzites of the Orange Grove Series. To the north of this again on the northern portion of Waterval No. 78, extremely clear examples of folding in the Witwatersrand beds are to be seen.

In comparing the degree to which the Lower Witwatersrand beds have been faulted with the comparative immunity of the Main Reef Series and the Upper Witwatersrand System from breaks of very great magnitude, it must be remembered that the Main Reef Series forms part of an almost continuous succession of very resistant quartzites some thousands of feet in thickness, while the Lower Witwatersrand beds consist of a number of individual quartzites separated by great thicknesses of shales and that these beds lie between the mass of quartzites just referred to and the granite, so that it is not surprising that in any movements which have taken place the lower portion of the Witwatersrand System has suffered the more serious degree of disturbance.

(*b*) *Rocks later than the Witwatersrand System.*

Within the area under review there are several occurrences of rocks which are in all cases almost certainly of later age than the Witwatersrand System, but whose relationships are difficult to determine with certainty, on account both of the faulted condition of the whole district, and especially of the isolated nature of the occurrences themselves. The most important of these are the beds occurring in Langerman's Kop, certain unconformable beds found on the northern side of the Bezuidenhout Valley, the Rietfontein Series, and the Bezuidenhout Valley Amygdaloid.

The Langerman's Kop Beds.

The hill known as Langerman's Kop is situated on the eastern suburbs of Johannesburg, and occupies the western half of the township of Kensington. It stands near the head, and commands a comprehensive view, of the Bezuidenhout Valley, above which it rises to a height of about 400 feet. The south-western portion of the Kop is joined by high ground to the Kensington Ridge, but on all other sides the Kop falls in steep rocky slopes to the lower ground which surrounds it. The length of the more elevated portion of the Kop is about one mile, with an average breadth of about one-third of a mile. Rock is exposed over practically the whole of the Kop, which presents one of the most complicated pieces of geology in the District. The whole of the rocks of the Kop show the effects of a considerable degree of shearing, which is so severe in the western portions as to render the exact determination of the dip of the beds, elsewhere well marked, a matter of difficulty. Where the Kop joins the Kensington Ridge the relationship of the Langerman's Kop rocks to those of the Witwatersrand System with which they are in contact, is clearly a faulted one. On all other sides the relationship of the rocks of the Kop to others in the neighbourhood, including the Bezuidenhout Valley amygdaloid, is obscured by talus and surface deposits by which the base of the Kop is surrounded. The most conspicuous rocks of the Kop, which cover the greater part of its surface, are coarse gritty quartzites, associated with numerous irregular beds and bands of conglomerate, made up mainly of pebbles of large size, many being from three to four inches in diameter, while individuals up to nine inches or more not uncommon. Both the quartzites and the conglomerates bear a very close resemblance to those of the Elsburg Series occurring to the south of Johannesburg, and the presence of very numerous pebbles composed of banded rocks similar in character to the Hospital Hill Slates, and of occasional larger pebbles or boulders of greenish quartzites, resembling closely those of the Hospital Hill Series, is usually regarded as an indication of unconformable relations to the Witwatersrand System. Apart from the size of the pebbles the conglomerates are characterized by rapid variations in thickness, and want of persistence of individual bands, while the quartzites show considerable inequality of texture and a tendency for the coarser particles to be enclosed in an abundant matrix of finer material. In a few places dark-greenish flaggy or shaly beds, a few feet in thickness, are also found. The Kop is generally supposed to be entirely composed of beds of the type just described, and also to show a consistent dip to the south in agreement with the Witwatersrand beds.

A detailed examination shows, however, that in neither of these respects do the rocks of the Kop agree with the view generally taken. A great part of the northern portion of the Kop, including almost the whole of the northern slopes, consists of quartzites of a type differing considerably from those of the southern slopes, and devoid of pebbles, while the eastern end of the Kop shows well-marked folding of its beds, resulting in these dipping northward at an angle of 60 degrees over a considerable extent of surface.

The quartzites which are exposed over the greater portion of the steep slopes of the northern face, and which form the crest of the ridge, resemble very closely those of the Witwatersrand System, occurring above the horizon of the Hospital Hill Series, similar quartzites occurring in the Kensington Ridge just south of the Kop, and in a minor ridge lying west of the Kop to the south of Kitchener Avenue. The change from the characteristic grits and conglomerates of the greater portion of the Kop to the quartzites forming its northern face follows a fairly well defined line running east and west along the higher portion of the crest of the Kop and ascending in a northerly direction to the low ground at points opposite Jupiter and Flora Streets; between which streets the northern slopes are composed of quartzites differing from those regarded as characteristic of the Kop.

Although the dips of both types of beds are in general very similar and throw little light on the relationships of the two, the marked difference in character of the quartzites points to unconformable relations, a view receiving considerable support from the conditions observable at the east end of the Kop, where the rocky slopes abut on King Edward Street, Kensington.

Here the gritty quartzites and conglomerates are underlain by masses of very hard fine-grained quartzite, still more different from the Langerman's Kop type than those seen on the northern face of the Kop. Between the two types of rock in most cases is a well-marked breccia, consisting of angular fragments directly derived from the lower quartzite and lying in a brownish sandy matrix. This is accompanied by a dark-greenish grit, containing unusually clear grains of quartz, and occasionally small pebbles, by the increase in the number of which the grit passes up into conglomerates of the Langerman Kop type. The conditions here presented are very similar to those frequently found along an unconformable junction, and render it extremely likely that such a junction is here represented, and that the Langerman's Kop beds thus form part of a formation unconformable to the Witwatersrand System.

The similarity of the Langerman's Kop beds to those of the Elsburg Series has already been referred to, and is so striking that it is difficult to come to any other conclusion than that they both belong to the same formation.

The view that the Elsburg beds are really unconformable to the Witwatersrand System is a view now held by many geologists, although over the greater portion of the Rand at least there is apparent conformity, and it is a matter of great difficulty to locate any line of demarcation between the two formations.

The Langerman's Kop beds with their large-pebbled conglomerates can be followed westwards beyond the limits of the Kop proper, to near the railway line, beyond which, along the same line of strike, the quartzites of the Government Reef Series, with occasional thin beds of small pebbles, appear at the surface, and may be traced across the town of Johannesburg. Outlying portions of the Langerman's Kop beds occur to the east of the Kop. Two of these lie about three-quarters of a mile from the Kop on either side of Ocean Street, Kensington. That to the east of the street consists entirely of beds of the Langerman's Kop type, while that to the west, like the exposures at the eastern end of Langerman's Kop, includes both coarse grits and conglomerates, and very fine-grained quartzites of the Witwatersrand type. A further occurrence of the big-pebbled conglomerates is to be seen in prospecting trenches in Kensington close to the eastern boundary of the township and near the Geldenhuis mill.

Unconformable beds on the north side of Bezuidenhout Valley.

On the north side of the Bezuidenhout Valley, about one and a quarter miles to the north-east of Langerman's Kop, certain beds are exposed which are distinctly unconformable to those of the Witwatersrand System upon which they lie. These beds, first noticed by Mr. Luttman Johnson, consist mainly of somewhat coarse brownish quartzitic sandstones, associated at the base with dark-greenish grits, which contain scattered pebbles and boulders, mainly of hard quartzite. Many of the boulders, which are well rounded, are over a foot in diameter, and some are very much larger. The beds, which crop out over a distance of half a mile, appear from below the edge of the amygdaloidal diabase, which appears to overlap them at either extremity. At their eastern end their base rests directly upon the ripple-marked quartzite, westwards from this point the line of junction passes obliquely across the strike of the Witwatersrand beds into successively higher horizons. Boulders are more numerous near the eastern end of the outcrop, and diminish towards the west, when shale fragments are common constituents of the basal beds, which thus appear to be markedly influenced in local character by the rocks upon which they were originally laid down. The beds show strongly developed shearing planes, which obscure the bedding, and render determination of the dip somewhat difficult. Where, however, the bedding planes can be best seen, they dip at an angle of about 50 degrees, thus differing but little from those of the Witwatersrand beds upon which they rest. In this respect there is a similarity between the relationships of these beds to the underlying formation, and those of the Langerman's Kop beds to the harder quartzites upon which they rest along the crest of the Kop, in both cases the difference of dip being very small. This also must be the case with regard to the beds of the Elsburg Series and the Witwatersrand System to the south of Johannesburg. The peculiar greenish grit with clear quartz grains which occurs at the base of the unconformable beds in Bezuidenhout Valley is so like that between the Langerman's Kop beds and the quartzites upon which they lie that the two can scarcely be distinguished. This similarity of the basal bed, and the general correspondence in relationships to the Witwatersrand System, as well as the proximity of the two occurrences to one another, suggest that the same line of unconformity is represented in both cases, and that the younger beds in both cases belong to the same formation.

The Rietfontein Series.

One of the most interesting and most debated points in the geology of the Rand is the question of the relationship to the Witwatersrand formation of the Rietfontein Series. This group of rocks occupies a considerable portion of the farm Rietfontein No. 145, ten miles east of Johannesburg. It includes the well-known Rietfontein conglomerates which have been successfully mined for many years and consists of a series composed mainly of quartzite, grits, and conglomerates, with some subordinate bands of shale.

The series has long been held by various geologists to be unconformable to the Witwatersrand System, although conclusive evidence has not been advanced in support of this view. On the other hand, on account of their apparent position as part of the lower Witwatersrand System, and their similarity in some respects to beds occurring elsewhere at an apparently corresponding horizon, they have also been regarded as forming part of the lower Witwatersrand System, a view which has led to very extensive prospecting for these beds in other localities. The view commonly held that the Orange Grove Quartzites pass north of the Rietfontein Series has perhaps been the main basis of the latter view. As shown above, however, the course of the Orange Grove Quartzites is considerably different from what is generally held to be the case, and this fact, together with the occurrence of granite on the southern portion of Rietfontein, against which the Rietfontein Series is faulted, renders the possibility of these rocks forming part of the Witwatersrand System extremely remote. The resemblance in general character of the Rietfontein Series to the Elsburg beds, and the beds of Langerman's Kop, has been remarked by numerous geologists, and is a point upon which even those holding the most diverse views as to the geological position of the series are agreed upon. The similarity of the Rietfontein Series to the beds mentioned is much greater than to any portion of the Witwatersrand System, and certainly as close as one would expect to find in a formation containing coarse conglomerates, and therefore more likely to show considerable differences in the composition of individual beds in different areas, and it seems extremely probable that the Rietfontein Series must be ultimately grouped with the Langerman's Kop beds and other similar rocks already referred to. It is noteworthy in this connection that both the Langerman's Kop beds and the Rietfontein Series, as well as the minor occurrences of similar beds to which reference has been made, are similarly placed with regard to the zone of faulting described above, to which they probably owe their present position.

With regard to the classification of these various groups of unconformable beds it has been suggested * that they should all, including the Elsburg Series, be grouped with the amygdaloidal diabase in the Ventersdorp System. More evidence, however, than that at present available as to the relationship of the diabase to the sedimentary beds, appears desirable before any close connection between the two can be said to be established.

The Amygdaloidal Diabase of the Bezuidenhout Valley.

In the Bezuidenhout Valley a very considerable area of the surface is occupied by the well-known amygdaloidal diabase, closely associated with breccias, which form part of the same suite of volcanic rocks.

The similarity of the amygdaloidal to that which is so conspicuously developed in the Klipriviersberg to the south of Johannesburg is so close as to leave little room for doubt as to the close relationship of the two occurrences. All the evidence presented by the Bezuidenhout Valley points to the northern margin of the diabase in that locality representing the natural plane of contact with the underlying rocks, although probably by no means the original margin of the flow, much of which has probably been removed by denudation.

The southern limit of the Bezuidenhout Valley amygdaloid roughly follows the zone of faulting described in the earlier portion of this report, and like the occurrences of sedimentary rocks younger than the Witwatersrand System has probably been to a large extent determined by it. It is difficult to accept the view sometimes put forward that the diabase fills a pre-existing valley. That the rock has taken part in many of the earth movements which have affected the locality is abundantly shown by the intense shearing it displays throughout the greater portion of its mass, while the general distribution of the amygdaloidal and brecciated types points to a synclinal arrangement of the whole, with a very steeply inclined southern limit. Such a structural arrangement, which is in agreement with the evidence afforded by the Witwatersrand System, sufficiently accounts for the great depth to which the diabase has been found to extend in boreholes put down near its southern margin, without the necessity of explaining the diabase as representing in part a large dyke following the trend of the valley.†

The amygdaloid probably extends much further west than is usually supposed to be the case since it was encountered in boreholes put down at both the reservoirs in Ellis Park, New Doornfontein.

An outcrop near Lang's Hotel, Rissik Street, has been recorded by Mr. Frames,‡ and a rock closely resembling the Bezuidenhout Valley diabase has recently been extensively opened up in a drainage tunnel cut under the railway at Vrededorp, west of Braamfontein Station, beyond which there are also indications of the presence of the diabase as far as the southern boundary of Brixton. A heavy covering of clay and red soil is very commonly found overlying the diabase, rendering it difficult to ascertain its limits with certainty, especially as somewhat similar deposits may be found over other local rocks.

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* Hatch and Corstorphine, "Geology of the Bezuidenhout Valley", p. 108.

† J. Zimmermann, Proc. Geol. Soc., S.A., Vol. VII, 1904, p. 44.

‡ M. E. Frame's Discussion on Hatch and Corstorphine Paper, Proc. Geol. Soc., S.A., Vol. VII, pp. 37-41.

III.

THE GEOLOGY OF THE STEELPOORT RIVER VALLEY

INCLUDING

THE COUNTRY ROUND ROOS SENEKAL AND DULLSTROOM

BY A. L. HALL (*Geologist*)

CONTENTS

1. INTRODUCTION.

2. GENERAL TOPOGRAPHICAL FEATURES.
   - (*a*) *The Valley of the Steelpoort River.*
   - (*b*) *Sekukuni's Mountains with the High Level Plateau to the West, and the Bothasberg.*
   - (*c*) *The Steenkampsberg and the country round Dullstroom.*
   - (*d*) *Drainage and Water Supply.*
   - (*e*) *List of Principal Heights.*

3. GEOLOGICAL STRUCTURE AND DISTRIBUTION OF THE LEADING FORMATIONS.

4. THE PRETORIA SERIES.
   - (*a*) *Quartzites.*
   - (*b*) *Shales.*
   - (*c*) *Altered Calcareous Rocks.*

5. THE DOLOMITE.

6. IGNEOUS ROCKS IN THE PRETORIA SERIES.

7. THE BUSHVELD PLUTONIC COMPLEX.
   - (*a*) *The Basic Margin.*
   - (*b*) *The Red Granite and Associated Rocks.*
   - (*c*) *Dyke Rocks.*

8. THE FELSITE OF THE LOWER WATERBERG.

III.—THE GEOLOGY OF THE STEELPOORT RIVER VALLEY, INCLUDING THE COUNTRY ROUND ROOS SENEKAL AND DULLSTROOM.

By A. L. Hall (*Geologist*).

1. Introduction.

The present report deals with the westerly and southerly continuation of field-work carried out in 1909.

During that year the mapping of the country west of the Drakensberg was carried on as far as a line drawn north and south through Adriaans Kop on the Olifants River, while in a southerly direction it terminated against a line drawn east and west through a point about four miles south of Pokwani, on the south-western side of Magnet Heights. In the present year the survey was continued towards the south up to a line drawn east and west through a point two miles south of Dullstroom.

The following account also includes a small area east of Dullstroom as far as the Machadodorp–Lydenburg main road, belonging to the basin of the Crocodile River and forming the western side of the Badfontein Valley, defined by the conspicuous ranges of the Steenkampsbergen. This special area forms the westerly continuation of field-work carried out during 1905.

The total area examined amounts to 1433 square miles, containing 624 miles of boundary lines.

Within the limits above defined the Transvaal System is restricted to the south-eastern portion (see Plate XI), and represented by the upper portion of the Pretoria Series down to about midway between the Magaliesberg and Daspoort Quartzites.

The remaining portion of the area is composed of norite with other basic varieties, the Red Granite, Nepheline Syenite, Granophyre and associated acid rocks, all connected with the Igneous Complex of the Bushveld and covering an extensive tract, including the whole of Mapochs country, belonging mainly to the northerly portions of the Middelburg District on both sides of the Steelpoort River.

A particular point of interest is the discovery of a further and extensive development of contemporaneous igneous rocks occurring in the highest horizon of the Pretoria Series west of Dullstroom.

2. General Topographical Features.

The country covered by the present report shows great diversities in physical features, similar to those described in previous Annual Reports in connection with the survey of the adjoining areas to the south and north-east.

The marked contrasts in surface relief, so characteristic of large portions of the eastern Transvaal, arise mainly from the varying degree of susceptibility to weathering influences, which the several formations present, combined with the powerful sculpturing action of the numerous streams—all containing good flows of perennial water, which form the drainage system of the Steelpoort and Crocodile Rivers. Thus the elevation varies from well over 7000 feet on the Steenkampsberg down to about 2800 feet on the lower reaches of the Steelpoort River. Within these limits, High Veld type of country, " Banken Scenery ", and true Bushveld country are all well represented.

(*a*) *The Valley of the Steelpoort River* belongs mainly to the Bushveld type of country, though the more usual Bushveld scenery is sometimes wanting and does not become permanently established until about the junction of the Mapochs with the Steelpoort River.

The country traversed by the latter stream forms a broad depression extending for some thirty miles roughly south-west to north-east, very sharply defined on the west by the conspicuous range of Sekukuni's Mountain. From the right bank of the river the country rapidly rises towards the south-east and presents highly diversified features, not built on any leading principle, since the bulk of the formations are igneous and belong to the norite margin of the Bushveld Plutonic Complex. The whole of this portion of the area is composed of norite and includes Mapochs country. It is bounded on the east by the high quartzite ridges of the Steenkampsbergen, some of which reach an elevation of over 7000 feet. Thus the eastern flank of the valley comprises the region between the Steelpoort River and the Steenkampsbergen averaging sixteen miles in width. It is characterized by a steady fall from east to west and includes some very mountainous, rugged and sometimes almost impassable country, drained by the Mapochs River, Tonteldoos Spruit, the Klip River, the Dwars River East, and the Dwars River West.

Broadly speaking, the country covered by the norite is similar to other parts of the eastern Transvaal, where the basic margin of the Bushveld Igneous Complex is well represented, but owing to the presence of several powerful streams and the marked hydrographic influence of the elevated ridges of the Steenkampsbergen, the country is much more dissected. Short somewhat irregular ridges alternate repeatedly with dark coloured rugged roughly pyramidal kopjes, some of which form conspicuous landmarks, e.g. Roos Kop, Zwart Kop, Galg Kop, etc. The whole aspect is highly typical of a region of plutonic rocks long subjected to subaerial denudation. That portion of the area which is traversed by the two Dwars Rivers and the Klip River is exceptionally wild and lonely, the surface being cut up by deep and narrow gorges, kloofs and gullies, so that it becomes practically impassable, except on foot, and on the whole useless from an agricultural point of view. For these reasons the whole of the norite area as far north-east of Mapochs country as the Lydenburg-Magnet Heights main road is almost uninhabited. The transition from the extreme westerly edge of the Pretoria Series to the norite country is effected in the same characteristic manner as in other parts of the eastern and central Transvaal, for the dip slopes of the uppermost Magaliesberg quartzite along the most westerly ridge of the Steenkampsbergen are succeeded by an almost level plateau, practically bare of outcrops, consisting of deep red soil, changing to the well-known black " turf ", wherever one approaches a drainage line. These features are very clearly seen on the farm Kliprivier No. 1314, which is traversed by the main road across the Steenkampsbergen connecting Lydenburg with Roos Senekal, via Oshoek. Furthermore, the first conspicuous outcrop of norite along this traverse is, as in the central Transvaal, a long belt of coarse rock, forming a more or less continuous series of pyramidal kopjes and shorter ridges, along the crest of which runs the boundary between Mapochs country and the Lydenburg District. The less hilly portion of the eastern side of the Steelpoort River Valley consists of small irregular areas usually devoid of marked relief and showing sometimes for several square miles nothing but the well-known deep reddish norite soil, with often detrital magnetite, e.g. Mapochs country specially south of Roos Senekal. Elsewhere, particularly nearer a drainage line, the familar black "turf" is conspicuous. Such more open and less wooded norite country gives very fair agricultural ground, e.g. De Lagers Drift and Broeder Stroom. Broadly speaking the further one proceeds north-eastwards along the main valley the more pronounced is the scenery and the wilder and more inhospitable becomes the norite country, at the same time the vegetation markedly increases with the general fall of country. From Roos Senekal northwards typical Bushveld country becomes well established (see Plate IX).

In the opposite direction, that is following the main valley to the south or upstream, the vegetation thins out rapidly, until from about De Lagers Drift onwards the surface is practically bare, only a very scanty vegetation being found restricted to the immediate neighbourhood of the main drainage lines. As the average elevation rises, so the kopjes and ridges of norite become fewer and less marked, the country gradually opening up and the valley becoming markedly shallow. Although the higher ridges of the Steenkampsbergen are still conspicuous, the scenery of the Steelpoort River Valley due west of Dullstroom now wears a much softer aspect, and still further south merges gradually in the Highveld country of the Karroo System.

(*b*) *Sekukuni's Mountains with the High Level Plateau to the West, and the Bothasberg.*—On the west side the valley of the Steelpoort River is much more sharply defined than on the east owing to the predominant feature of Sekukuni's Mountains and the Bothasberg.

Sekukuni's Mountains from an extremely well marked escarpment which presents a steep slope towards the east and runs roughly parallel to, and at an average distance of about three miles of the Steelpoort River. The crest line keeps at a fairly uniform elevation for considerable distances, and since the escarpment is only occasionally cut up into well defined peaks, it resembles rather a continuous range than a series of high points. Although on looking from Roos Senekal westwards, Sekukuni's Mountains give the impression of a high range (see Plate IX), the escarpment is in reality the eastern edge of the wide high level plateau of granite, etc., which embraces Pokwani and a considerable stretch of the more northerly portion of the Middelburg District. This plateau has been cut through by the Steelpoort River, and the more rapid erosion of the underlying norite formations has helped to accentuate the resulting topographical contrast. Owing to the rapid fall of the country from south-west to north-east both the escarpment of Sekukuni's Mountains and the resulting contrast in the relief become increasingly more marked in the same direction, so that finally the difference in level between the river and the edge of the plateau overlooking it amounts in places to over 2000 feet. Towards the south Sekukuni's Mountains continue as far as Tautesberg, and at the same time the elevation at its crest line above the Steelpoort River becomes gradually less. While on the whole the edge of the plateau is very sharply cut and may thus remain as a markedly regular feature for several miles, the continuity is now and then broken, through the agency of short tributaries joining the main stream from the west, e.g. on Buffelskloof No. 196, and Tygershoek No. 1318, hence the escarpment recedes and may sometimes be cut back considerably, or give place to more isolated peaks rising above the high plateau, e.g. on Eenzaam and Spitskop. In places the main escarpment is extremely precipitous and where at the same time the crest line persists at a uniform elevation the resultant effect is very similar to the escarpment of the Drakensberg south of Belvedere; when viewed from some positions on the east side of the Steelpoort River this strong resemblance to the behaviour of a sedimentary formation slightly inclined to the west becomes so marked that it is difficult to realize the granitic character of the mountain range.

The term Sekukuni's Mountains is restricted to the main escarpment described above, which ends abruptly at the Tautesberg. But topographically the range continues by turning sharply towards the west and keeping along the right or north side of the Blood River, constantly decreasing, however, in elevation above the latter stream, when followed from Tautesberg westwards.

The Bothasberg answers both topographically and geologically to Sekukuni's Mountains and is confined, within the limits of the present area, to the south-western corner. It likewise presents the eastern and western termination of a great plateau, in this instance composed mainly of felsites and other formations belonging to the Waterberg System. Compared with Sekukuni's Mountains, the Bothasberg is not nearly so well marked, nor does it show such precipitous slopes, but forms a semi-circular ridge gradually dying down in topographical effect as it is followed southwards towards its disappearance below Karroo formations. The wide strip of norite country between Tautesberg and Stoffberg thus forms a kind of nek or watershed between the Steelpoort and Blood Rivers. The peculiar distribution of the boundary lines in this area is discussed below.

The High Plateau north of Sekukuni's Mountains belongs in certain respects to the High Veld type of country since its average elevation is well over 5000 feet, the vegetation being generally quite subordinate or even wanting entirely. It forms a wide somewhat monotonous rolling tableland, occasionally diversified by swelling bults, rising now and then into distinct prominence, notably on Vaalkop and Paardekop (*6221 feet above sea-level). In one or two cases it is, however, deeply dissected by the tributaries draining the Blood River, when the resulting relief becomes at places highly pronounced. The rocks composing the plateau consist mainly of granophyre, granite, and felsite. In case of the two former the scenic influence is nearly the same, and wide stretches of gently undulating—

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* Trigonometrical Survey Level.

sandy country are the rule, e.g. between Pokwani and Paardekop—but on the whole the granophyre area shows more diversity than the granitic portion. The felsite generally gives rise to fairly level country with smooth and rounded hills, but owing to the character of the formation there is very little soil, while the sudden appearance of deep precipitous kloofs, e.g. along Diepkloof Spruit, is also highly characteristic.

(*c*) *The Steenkampsberg and the country round Dullstroom.*—The name Steenkampberg is applied to the long stretch of high ground which extends from Dullstroom roughly in the northerly direction for some twenty-six miles, and consists of a number of quartzites with intervening crystalline slates and intrusive sheets, making up the Magaliesberg beds.

Round Dullstroom itself the ridges within this high country are not very marked, though the elevation is in places well over 7000 feet, but the further one proceeds northwards the more marked becomes the individual quartzite, so that the high rolling tableland is gradually resolved into several distinct ridges, which from Boshhoek's Hoogte northward are separated from one another and give rise to well-marked ranges, usually composed of quartzite with escarpments facing eastward. The general plan of the leading topographical lines may thus be likened to a hand—the fingers, slightly opened and pointing northward corresponding to the several ridges, while the palm answers to the high veld country round Dullstroom, where the various quartzites have lost their individuality as distinct ridges.

The most easterly of these corresponds to the lowest quartzite bands of the Magaliesberg horizon and forms the very striking wall-like range which borders the Badfontein Valley on the west. It is by far the most striking feature, when passing along the Machadodorp-Lydenburg main road between Schoeman's Kloof and Witklip, and some of the conspicuous peaks rise well over 2500 feet above the general level of the Crocodile River Valley. The low westerly dip combined with the considerable thickness of the quartzite produces very fine precipitous krantzes, marked by powerful waterfalls. In a southerly direction,* after crossing the Crocodile River, this portion of the Magaliesberg beds gradually dies out topographically, but still shows as a belt of high ground conspicuous by a continuous line of whitish outcrops, whence the feature obtains the local name of " Witrand ". Towards the north, the Witrand continues past Badfontein and Witklip and, soon after crossing the Lydenburg Railway, becomes differentiated into two separate ridges, separated by hard crystalline altered slates and intrusive sheets. The more easterly of the two forms the conspicuous range of the Steenkampsbergen proper, which at once arrests the attention on looking from Lydenburg westward. The other ridge lies only a mile or two further west and passes through Boshhoek's Hoogte, as previously described.†

On proceeding from the Crocodile River Valley at Badfontein westwards and traversing the precipitous range alluded to above, the country quickly rises towards Dullstroom in a series of further ridges, composed sometimes of hard crystalline altered slates, sometimes of quartzites, the whole of the country presenting a high degree of complexity in surface relief, owing, among other causes, to the numerous powerful tributaries of the Crocodile River. Another quartzite crosses the eastern portion of Elandslaagte a few miles east of Dullstroom and forms a fairly well-marked ridge, passes across the farm Lunsklip, where it is deeply dissected by a rushing torrent from Verloren Vlei and develops some remarkably fine scenery. From Lunsklip northward it is more and more sharply defined as a separate range, running first on the right side of the Waterval River and finally crossing that stream. Since the Lunsklip quartzite is, however, distinctly thinner, and associated with hard altered slates both above and below, the ridge in which it shares is geologically composite.

Immediately west of Dullstroom, over the farms Elandshoek No. 2, Onverwacht No. 210, Verloren Vlei No. 1316, Klipbankspruit No. 1443, Kliprivier No. 1314, and Wanhoop No. 7, there lies a wide belt of very high ground in places over 7000 feet above sea-level, composed mainly of bare swelling " bults " and gentler ridges of quartzite, with typical High Veld characters. This includes the gentle, but well defined escarpment, seen when looking from Dullstroom Station in a north-north-easterly direction ; the above high ground belongs to the upper horizon of Magaliesberg beds. While towards the east there is a rapid but gradual fall, on the west side the country is broken and falls steeply towards the norite plateau. The resulting relief is well illustrated by the scenery along the main road connecting Lydenburg, via Boshhoeks Hoogte and Oshoek, over the "Steenkampsberg", with Roos Senekal.

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* See W. A. Humphrey, Annual Report Geological Survey, 1906, p. 103.

† See A. L. Hall, Annual Report Geological Survey for 1909, p. 56.

Oshoek No. 1442 lies in the valley of the Waterval River, which is defined on the east by the ridge comprising the Lunsklip quartzite, and on the west by the extreme western range of the Steenkampsberg. Proceeding from this farm along the main road towards Roos Senekal, the floor of the valley rapidly rises and terminates in a sharply defined mountain kettle over the common boundary between Potspruit No. 1188 and Wanhoop No. 7, the two flanks of the valley becoming united. After a short and steep ascent one enters the wide and almost level sandy plateau on which Wanhoop No. 7 and Verloren Vlei No. 1316 are situated—a typical piece of bare high veld at an average elevation of 7000 feet. Here the road turns sharply to the north-west, reaches its highest point of about 7100 above sea-level in the northern portion of Wanhoop, and then crosses some superb scenery, while descending in a series of curves down to the low-lying norite country—the difference in level amounting to about 1600 feet. The high plateau of Wanhoop is locally known as Steenkampsberg. Over Klipbankspruit No. 1443, Houtenbeek No. 191, and Onverwacht No. 210, the transition zone between the uppermost Magaliesberg quartzite and the norite country on the west gives rise to wild highly dissected country, deeply furrowed by numerous kloofs and gullies.

The most westerly range of the Steenkampsbergen runs in a northerly direction from the Wanhoop plateau, and defines the left side of the Waterval River Valley for some miles, making a regular and conspicuous ridge through the farms De Berg No. 547, Kaffirskraal No. 630, Schaapkraal No. 442, and Vygehoek No. 1194, and ending abruptly (for reasons considered below) in a high prominent kopje near the common beacon of Naauwpoort No. 1432, Vygehoek No. 1194, and Modderspruit No. 1361. This kopje is a most prominent landmark in the Waterval River Valley.

(*d*) *Water Supply and Drainage.*—The amount of available water shows a simple and direct connection with the distribution of the principal formations, and three broad divisions may be recognized, each with distinctive hydrographic conditions.

Over the high ground round Dullstroom, eastward as far as the edge of the escarpment overlooking the Crocodile River Valley opposite Badfontein, and westward along the ridge of the Steenkampsbergen there is a very good water supply. This arises from the fact that the high plateau round Dullstroom with its extensive sandy tracts, derived from the prolonged weathering of the arenaceous facies of the Magaliesberg beds, forms an area highly favourable to increased precipitation, while at the same time the nature of the surface and its gently rolling character tend to increase percolation and diminish the run off. Hence much of the rainfall is retained underground and only returned to the surface gradually, so that practically all the streams are perennial. For similar reasons, vleis are fairly common and may sometimes attain large dimensions like the remarkable occurrence on Verloren Vlei, situated on the quartzite at an elevation of some 7000 feet and about half a square mile in extent, with an almost imperceptible fall towards the north-west and draining a perennial stream of very pure water which makes a series of falls and cascades over the ridge, in which lies the common boundary of Klipbankspruit No. 1443 and Verloren Vlei No. 1316. There are good indications of a strong underground supply almost everywhere over the whole high plateau north of Dullstroom and the characteristic vegetation of well watered elevated tracts is represented by such types as the sugar bush and the tree fern. The most important stream is the Crocodile River with its numerous tributaries among which the one rising in the eastern portion of Verloren Vlei and traversing Lunsklip carries a fine body of pure water. The prevalence of a series of quartzites with a low westerly dip and often giving rise to escarpments and cliffs accounts for the frequency of waterfalls, some of which assume striking proportions, e.g. on Lunsklip No. 1446 and Waterval No. 652.

The second area with distinctive hydrographic features is practically conterminous with the distribution of the norite and has a much poorer supply of surface water. It is drained by the Steelpoort River with its numerous tributaries, Zwartspruit, Broederstroom, Mapochs River, Klip River, and Dwars Rivers. A small portion of the Bloed River basin also falls within the present area. While in the neighbourhood of these major streams the supply of water is good, the bulk of the country further away has a poor supply, as is usually found to be the case over the norite formation, which in this respect differs markedly from quartzite. It was shown above that the bulk of the area covered by norite constitutes very hilly and rugged country, and this reason, combined with the poor water supply, accounts for the fact why such large tracts of the present portion of the Steelpoort River Valley, i.e. the south-eastern portion of Mapochs country and the area east of the Klip River are unsuitable for agriculture.

To the hydrographic basin of the Steelpoort River also belong the remarkable springs of lukewarm mineral water on Buffelskloof, a short distance east of the Steelpoort River, said to possess powerful curative properties.

Finally, the granitic plateau west of the Steelpoort River enjoys a very fair supply of permanent surface water, while indications of underground sources are also good. The general hydrographic conditions bear a certain resemblance to those of the high veld round Dullstroom, since the granitic plateau lies also at a considerable elevation, is terminated on the east by the wall-like escarpment of Sekukuni's Mountains, and consists of large sandy tracts, which provide suitable soil for retaining moisture. Though the main drainage lines carry less water than those of the Crocodile and Waterval River basins, the supply is usually permanent and the general character of the surface indicates a good underground supply which could be tapped at no great depth, specially where Bushveld granite predominates. The belt of high granophyre country on which Paardekop and Vaalkop are situated forms a favourable area of precipitation and on it rises Deepkloofspruit, a powerful stream which conveys a strong body of permanent water to the Olifants River. Owing to the prolonged westward erosion of a few minor streams one occasionally finds small areas of the granitic plateau, the drainage of which has been deflected eastward to join the Steelpoort River, e.g. Eenzaam No. 462 and Spitskop No. 465, south-east of Pokwani.

(e) *List of Principal Heights.*—The following table gives the heights above sea-level of the more important points covered by the present report. The values are only approximate, excepting those referring to trigonometrical survey beacons and railway levels.

Verloren Vlei, six miles north of Dullstroom	7454
Steenkampsberg (Wanhoop)	7250
Dullstroom Station	6803
Santa Siding (Lunsklip)	6442
Paardekop	6221
Kliprivier (centre of farm)	5850
Near north-east beacon of Vygehoek (left side of Waterval River)	5850
Oshoek (Waterval River Valley)	5800
Tauteshoogte (Sekukuni's Mountain)	5750
Tonteldoos (Mapochs country)	5500
Stoffberg Police Post	5450
Vaalkop	5400
Boschfontein P.O.	5000
Tautesberg Police Post	5000
Blinkwater Store	4950
Drift in Deepkloof Spruit on main road	4910
Witpoort (ten miles west of Dullstroom)	4900
Roos Senekal	4500
Kopie Alleen (Badfontein Valley)	3850
Badfontein Store	3550
Steynsdrift (Steelpoort River)	2950
Buffelskloof (Hot Springs)	2750

3. GEOLOGICAL STRUCTURE AND DISTRIBUTION OF THE LEADING FORMATIONS.

The geological structure of the present area is built on a simple plan, though, owing to the intrusion of the Bushveld Plutonic Complex, numerous minor complications have resulted along the top of the Magaliesberg beds which do not, however, affect the main principle.

Sedimentary formations are confined entirely to the eastern portion and belong to the upper horizons of the Pretoria Series; they coincide roughly with the distribution of the high ground along and round the Steenkampsbergen, north, west, and east of Dullstroom, while the main valley of the Steelpoort River, including the whole of Mapochs country and the high plateau westwards are made up solely of igneous rocks. The dip of the quartzites, shales, and other stratified rocks is uniformly towards the west, varying from a few degrees up to about twenty, and as usual round the edge of the igneous basin, the values slowly increase on rising in the succession and approaching the basic margin of norite. The sinuosities in the outcrops of the leading quartzites are mainly due to the high degree of sculpturing which the surface has undergone, and indicate the marked degree of erosive action on beds differing in their capacity for reacting on weathering influences. It will be noticed, on glancing at the map in plate XI, that, west of Dullstroom, the distribution of the quartzites becomes more irregular as one approaches the norite, a result of tectonic disturbances consequent upon the intrusion of the Bushveld Complex, but the scale of the map only admits of a more generalized representation of the numerous minor irregularities. The complicated manner in which individual quartzites are broken across, displaced and entangled by the intrusive norite magma, is well illustrated on the farms Windhoek No. 443, Onverwacht No. 210, and Houtenbek No. 191, a few miles west and north-west of Dullstroom. As a rule, the more prominent quartzites persist, when traced northward, while in several cases, the thinner bands die out; a notable instance of the abrupt termination of the main Magaliesberg Quartzites will be discussed below.

Lying conformably interbedded within the Pretoria Series, one finds the usual prevalence of intrusive sheets, which do not, however, present any special structural features.

Considerably more than half the present area is made up of plutonic igneous rocks belonging to the Bushveld Complex. They are divisible into an acid group, mainly granite, and a basic group, mainly norite, confined respectively to the country west and east of Sekukuni's Mountains. The relative areas covered by these two groups are determined by magmatic differentiation in such a way that the basic members lie in contact with the sedimentary belt of the Pretoria Series. The distribution of the norite west of Dullstroom, where the basic rocks form a bay extending westwards into the granite area along the Blood River, shows that the belts of acid and basic rock behave topographically like sedimentary formations having a low westerly dip. This follows from the general character and mode of origin of the Plutonic Complex, which forms a kind of laccolite, the lower or basic stratum being succeeded above by the upper or granitic stratum. The direction of dip being determined by that of the sedimentary floor (i.e. Pretoria Series), the presence of the "nek" of norite between the granitic ridges of Sekukuni's Mountains and the Bothasberg is readily understood. Hence the norite very probably passes with a gentle dip westwards underneath the red granite. The present area therefore fully bears out previous experience in Sekukuniland and elsewhere regarding the stratified structure of the lower portion of the Bushveld Complex, and its consequent behaviour like a slightly inclined sedimentary bed when subjected to the processes of land sculpture.

4. THE PRETORIA SERIES.

Rocks belonging to the uppermost division of the Transvaal System comprise quartzites and shales, but intrusive sheets with diabasic affinities are unusually prominent and make up almost half the entire thickness, especially round Dullstroom. Owing to the low dip and varying susceptibility to weathering influences, the quartzites stand out as linear features and the resultant relief sometimes recalls the familiar "banken" scenery. The general share of the Pretoria Series in forming the character of the topography has been pointed out above.

(*a*) *Quartzites*.—All the various quartzites shown on plate XI belong to the Magaliesberg horizon, which is thus represented by at least five separate bands; in this respect the uppermost division of the Pretoria Series as developed in the present area differs markedly from that seen along the type section west of Pretoria, where one or at most two quartzites are found, occupying a width of about one mile. Along the Dullstroom section the country from the edge of the norite to the base of the lowest Magaliesberg Quartzite measures at least thirteen miles in width. It follows therefore that the condition of deposition must have varied considerably, and can in no way be accounted solely by the lower dip in the Dullstroom area.

Four main quartzites may be distinguished, which give rise to prominent and persistent features. They correspond strictly to the four bands described in the previous Annual Report* in connection with the Survey the area west of Lydenburg. The same enumeration is adhered to in the present report, No. 1 being the lowest and No. 4 the highest main quartzite. East of Dullstroom, however, the two lowermost bands (Nos. 1 and 2) are practically superimposed in the great range of the Steenkampsberg, which overlooks the Crocodile River Valley from the west, so that on plate XI only three main bands are shown, while on the map illustrating the area further north, e.g. along the main ridge west of Lydenburg, on which Boshhoek Hoogte lies, they are indicated separately owing to the greater thickness of intervening altered shales and intrusive sheets (see Annual Report of Geological Survey for 1909, Plate XII).

Towards the south the most easterly escarpment of the Steenkampsbergen gradually dies out, but the two quartzites still persist and make a distant feature—known as the Witrand—in the High Country north-west of Machadodorp. The thickness of these two bands varies considerably, and east of Badfontein the collective thickness is probably somewhere near 1000 feet. Quartzite No. 3 is considerably thinner and, being associated, both above and below, with a considerable body of intrusive diabasic sheets, does not give rise to such distinctive features as in the case of No. 1 and No. 2. South of Dullstroom it is well exposed, where the main road to Belfast crosses the farm Lakenvlei No. 1081, but here it scarcely stands out at all from the general level of the High Veld country. Further north, while traversing Elandslaagte and Morgenzon east of Dullstroom, it begins to assert itself topographically and becomes very evident on Lunsklip, where the railway line cuts across it. Just north of the last-named farm the quartzite gives rise to a piece of high plateau-like country, which forms the gathering ground for the sources of the Lydenburg Dorp River and the Waterval River, and finally continues as a ridge of high ground marking the divide between the valleys due to the above-mentioned streams. The continuity of this band is locally broken by the intrusion of igneous sheets of great thickness as e.g. along the common boundary of the farms Oshoek No. 1442 and Schaapkraal No. 442, and further north where Boschfontein and Koppieskraal join. As quartzite No. 3 is traced down the Waterval River, it becomes much less marked as a distinctive topographical feature, owing to the presence of the more prominent escarpment of the uppermost quartzite further west.

The highest main quartzite, No. 4, makes a somewhat broad band west of Dullstroom and is very evident as a distinct escarpment, well seen on looking from Dullstroom Station northward. It forms a stretch of bare elevated country stretching through the farms Paardeplaats, Elandshoek, Onverwacht, and Verloren Vlei. From the adjoining farm, Wanhoop, the ridge becomes gradually more marked, and as the formation is traced northward along the left side of the Waterval River Valley, it develops a very prominent ridge, one of the best marked spurs of the Steenkampsbergen, and continues as such for some sixteen miles from Wanhoop northward, finally coming to an abrupt termination at the common beacon of Vygehoek, Modderspruit, and Naauwpoort. Near this point quartzite No. 4 has a thickness of about 250 feet, and the sudden termination of a bed of such dimensions is remarkable. There is no definite evidence of faulting, for the underlying quartzite No. 3 in the floor of the valley is continuous. A little to the west of the prominent kop, a further quartzite appears in the low norite flats following on the dip slopes of No. 4 quartzite, and the two might be regarded as identical, but there is a marked decrease in thickness in case of the more westerly band, which moreover rests on altered shales, whereas quartzite No. 4 rests on igneous rocks. The general distribution of formation round Naauwpoort, combined with the locally disturbed character of some of the beds suggest that during the intrusion of the Bushveld Complex the higher quartzites were broken across and displaced vertically, some portions being raised and removed by denudation before others. The remarkable termination of No. 4 quartzite at Naauwpoort bears a strong resemblance to a similar occurrence

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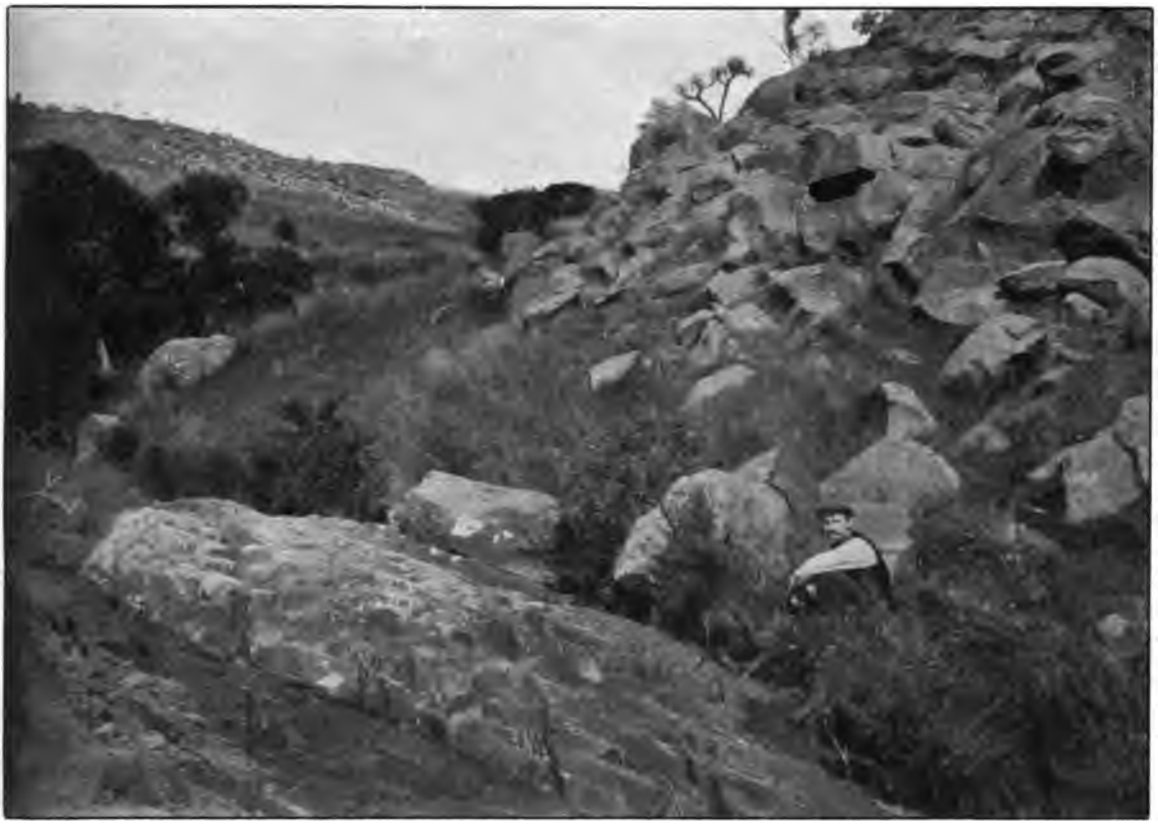
* Annual Report Geological Survey for 1909, p. 62.



Junction between top of Pretoria Series and Norite margin of Bushveld Complex,
near Oshoek No. 1442, Lydenburg District.

near Uitloop, south of Potgietersrust, where the black reef quartzite comes likewise to a sudden end and reappears a few miles off, the intervening portion being occupied by rocks belonging to the igneous complex of the Bushveld.*

It was pointed out above that the more prominent ridges of the Steenkampsbergen are due to the thicker quartzites which form the familiar escarpments facing eastwards. For some miles along the left side of the Waterval River Valley, quartzite No. 4 forms an interesting and striking exception to this rule, for over the farms Schaapkraal No. 442 and Kafferskraal No. 630 the base of the quartzite runs right over the ridge and lies almost at the foot of the slopes facing westwards, while the main ridge continues uninterrupted, but made up of the underlying intrusive rocks.

In addition to the above described series of four main quartzites a number of additional bands are well exposed at numerous localities. Such extra quartzites are usually quite subordinate and do not exceed a few yards in thickness. They can be very clearly studied on Oshoek in the upper valley of the Waterval River, also in the farms Houtenbeek, Windhoek, Konterdanskloof, and Paardeplaats, west and south-west of Dullstroom, where two thin bands occur above main quartzite No. 4 which show much local disturbance and are sometimes highly contorted and generally thrown about. Similarly, on the farms Vygehoek No. 1194, Schaapkraal No. 442, and Kafferskraal No. 630, a thin but persistent band occurs in the norite plateau which succeeds the dip slopes of No. 4 quartzite westward and borders the right side of the valley of the Dwars River east. At least two such extra quartzite bands are also found below No. 4 quartzite along the western slopes of the Waterval River Valley. Fig. 1 illustrates the detailed succession seen across the common boundary of Moddersspruit No. 1361 and Vygehoek No. 1194.

SECTION ACROSS THE VALLEY OF THE WATERVAL RIVER, SHOWING THE SUCCESSION NEAR THE TOP OF THE MAGALIESBERG QUARTZITE SERIES.

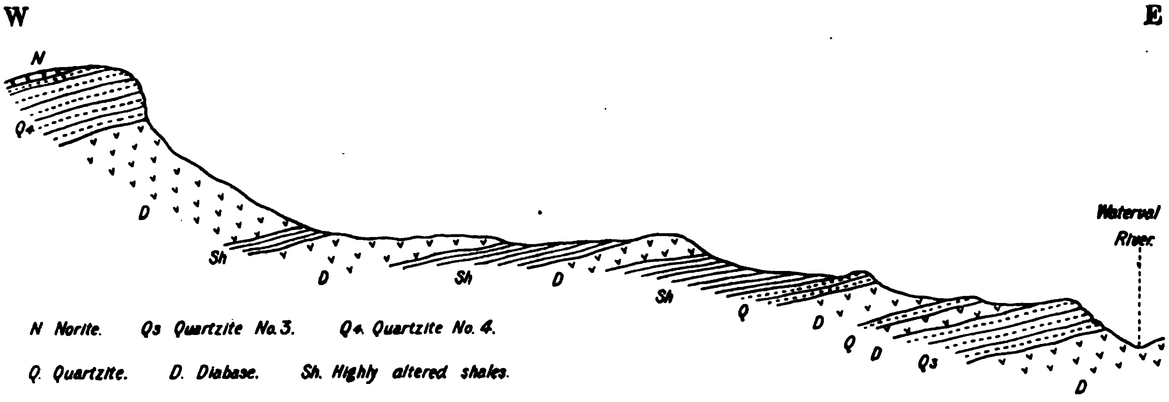


Fig. 1.

Petrographically the various quartzites of the Magaliesberg horizon show considerable resemblance to one another, and it would be impossible to discriminate between the different beds by examination of hand specimens alone, except when the metamorphic influence of the igneous rocks has been specially marked. Normally they are light coloured, rather fine-grained fresh rocks, with characters very similar to those usually found in the quartzites of the upper portion of the Pretoria Series, and nothing need be here added to descriptions given in earlier annual reports.

The changes which some of the quartzites undergo when subjected to the direct influence of intrusive rocks, result in some remarkable variations, especially when the original rock was somewhat argillaceous. A very fine illustration occurs on the farm De Berg in connection with the highest main quartzite, which can be seen in sharp contact with the extreme edge of the basic margin of the Bushveld complex; the outcrop is shown in

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* See Annual Report Geological Survey, 1908, pp. 13 and 70.

Plate VIII. The uppermost layers of quartzite No. 4 pass with a well-defined dip directly underneath the igneous rocks, and the line of contact has been well exposed by a little stream which follows the junction for some distance. The quartzite must have been originally very pure, because no contact minerals are found in it, but it has become glassy and undergone complete recrystallization into a very coarse rock. Such recrystallization is commonly found along horizons in close proximity to the margin of the Bushveld Complex, notable examples being met with along the main road connecting Oshoek with Roos Senekal on the south-eastern portion of the farm Kliprivier, where the road descends over the dip slopes of No. 4 quartzite; or at the summit of the prominent kop in which this band comes to an abrupt end west of the Waterval River. In such cases the recrystallized grains tend to assume the form of dihexagonal pyramids, while any original felspathic matrix develops small muscovite flakes ($98c_3$).[*] On the summit of the ridge overlooking Oshoek from the west, certain layers in the main quartzite become spotted with small patches of bluish black iron ore, while thin sections are crowded with very slender colourless needles of a mineral showing high refractive index, combined with low double refraction and suggesting in its optical behaviour a member of the Zoisite group.

Further south, on the high plateau of Wanhoop ("Steenkampsberg"), the lowermost beds of No. 4 quartzite consist of a highly metamorphosed type ($107c_3$), well exposed just north of the main road and about half a mile south-east of the highest point in that road. The rocks are fine-grained and dark coloured with greyish weathered surfaces, no minerals are visible in hand specimens excepting quartz, but the thin section contains numerous small grains of andalusite and slender needles or rosette like aggregates of sillimanite; it is probable, therefore, that the original rock was somewhat impure and argillaceous.

Mention may here be made of another quartzite which cannot be correlated with any of the three recognized horizons of the Pretoria Series, as it occurs quite isolated in the norite and red granite in the extreme western portion (see Plate XI) on the farms Leeuwfontein No. 96, Wintershoek No. 19, and Blaauwbank No. 34, and extending from the valley of the Kruis River into that of the Bloed River. Its presence was noted by Dr. Mellor[†] in 1906. Towards the north it terminates on Blaauwbank at the junction between the norite and granite, where it forms a prominent outcrop close to the old homestead about 2½ miles from the store. The rock is a sharply jointed light coloured quartzite with sometimes much felspathic matrix, dipping to the south-east and resting on the bushveld granite. From the homestead this quartzite can be traced south-westward across Wintershoek and Leeuwfontein, generally making a slight feature in the scenery. Over the western corner of the last-named farm the rocks make a distinct ridge cut by a small poort which conveys the tributary coming from the north. The quartzite is very glassy and fresh, and is overlain by ribbed or banded greyish rocks, in places highly contorted, which represents highly altered shaly quartzite. The total thickness is about 100 feet and the influence of the norite magma, which on Leeuwfontein occurs both above and below the sedimentaries, is reflected in the composition of the banded rocks ($179c_3$ to $182c_3$) which contain much pyroxene.

It is seen from the above remarks that the pure quartzites, under the influence of metamorphism, are merely recrystallized with practically no formation of fresh minerals (excepting muscovite), but that even a slight impure shaly admixture gives rise to new contact minerals—sillimanite and andalusite. In some cases considerable successions of quartzite are thus affected.

In the case of the numerous intrusive sheets, in which the Magaliesberg horizon abounds, the contact alteration becomes much less marked. Thus on Schaapkraal, a few miles west of Vermont Siding (Wemmershoek), the base of No. 3 quartzite has been directly affected by the underlying intrusive sheet, and the rock has become injected by diabasic material, which weathers out more rapidly and thus gives the quartzite a highly characteristic appearance ($105c_3$ and $106c_3$). Such alteration is strictly limited to the immediate junction with the underlying igneous rock. The best outcrop is found a little west of the road connecting Wemmershoek with Oshoek and about three-quarters of a mile north of Mohlmann's Homestead (see Fig. 2, p. 52).

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[*] Such numbers denote the rock specimens deposited in the Museum of the Geological Survey.

[†] Annual Report Geological Survey for 1906, p. 69.

(*b*) *Shales*.—The argillaceous facies of the Pretoria Series is represented along the Steenkampsbergen and east of Dullstroom by a considerable body of shales, sandy shales, graywackes and similar rocks, the bulk of which are more or less highly altered. In their general characters there is a close resemblance to analagous rocks from the northerly extension of the present area, an account of which is given in the Annual Report of the Geological Survey for 1909.* The more normal unaltered shales are confined to the lowest horizons below quartzite No. 1 of the Magaliesberg Series and are well represented in the Crocodile River Valley round Badfontein, from the Lydenburg-Machadodorp main road as far westwards as the lower slopes of the conspicuous range overlooking the Badfontein Valley. Owing to their soft nature such normal shales usually occupy the low flats and do not rise into conspicuous features, except nearer the quartzite escarpment. These unaltered varieties behave generally like typical Pretoria shales, but in places they tend to become graphitic as is frequently the case in the Lydenburg District.

Metamorphosed Shales comprise a great variety of types ranging from slightly altered and indurated flagstones up to hard black holocrystalline medium grained cordierite rocks. They are permanently established from a horizon a little above quartzite No. 2, e.g. as far east of Dullstroom as Kareekraal No. 219, and from here westwards normal shales are practically wanting. For reasons which need not be given here the agency of the metamorphism is the intrusion of the main body of the Bushveld Complex, and to a much smaller extent, the presence of intrusive sheets of diabasic character. Hence the more one approaches the western slopes of the Steenkampsbergen, where the sedimentary rocks are in direct contact with the norite, the more highly are the shales altered.

The commonest varieties are fine-grained, dark coloured, hard slates, rarely showing any minerals visible to the naked eye. Owing to their hard nature, they much more readily withstand weathering influences and frequently form ridges or kopjes, differing in this respect essentially from the unaltered rocks. East of Dullstroom this effect is well seen over the farms Rooiklip No. 463, Karrekraal No. 219, Kruisfontein No. 1033, and Elandspruit No. 462. Thin sections show a completely recrystallized matrix, usually replaced by a fresh quartz felspar mosaic, while cordierite in colourless plates is widespread. The further one proceeds westwards, the more thoroughly has recrystallization been affected, and at the same time the texture is slightly coarser. On Houtenbeek and elsewhere along the edge of the norite, larger masses of quartzite and shale have been torn off and become entangled in the norite magma; under such conditions the shales have undergone profound metamorphism and are converted into thoroughly crystalline rocks, altered almost beyond recognition.

Such "xenoliths" have in consequence a distinctive mineralogical composition owing to the influence of the basic magma. The hand specimens reveal abundant brown mica and blebs of fresh quartz, while the brown weathered surface is dotted with small knotlike excrescences probably of cordierite. The latter mineral is well represented, together with typical metamorphic biotite, while the bulk of the rock consists of pyroxene, which forms a fairly even granular groundmass with a few larger crystals. It is obvious therefore that during metamorphism the original shale was materially affected by certain constituents of the norite magma. Sometimes the shales become altered under the influence of intrusive sheets and highly remarkable rocks are then produced. It was pointed out above that the main agent of metamorphism is the Bushveld Plutonic Complex, and as a rule it is not difficult to define the width of its contact belt. But within the latter, numerous intrusive sheets occur, and it may become very difficult to distinguish the particular metamorphism due to them. Commonly the shales intervening between two neighbouring intrusions are converted into a uniform succession of black, fine-grained cordierite hornfels throughout their entire thickness. Such cases seem to show, in their extent and distribution, a direct connection rather with the body of the norite than with intrusive sheets, so that to the latter we must assign only a minor contributory share in the metamorphism. Immediately along the contact with such sheets the shales present highly characteristic appearances, due undoubtedly to the intrusive bodies only. A very instructive section occurs on Oshoek No. 1442, in the valley of the Waterval River, from the mill, situated about the centre of the farm and on the left bank of the river, westwards towards the higher slopes of the ridge, marked by the escarpment of No. 4 quartzite. Along this section at least two thin bands of quartzite are found, together with several intrusive sheets and various horizons of altered shale. About midway between the two quartzites good exposures are seen of the line of contact between altered shales above and intrusive igneous rocks below. Resting directly on the latter occurs a thin belt up to about 3 feet in width of hard, close-grained, dark, greenish grey banded rocks, the banding running conformable to the bedding planes of the shales. Owing to the differential rate of erosion the brown weathered surfaces are characteristically ribbed. A fresh surface shows alternate pale-green and almost black bands. In the field these rocks behave like a well-bedded sedimentary formation, but in thin section pyroxene and serpentine make up practically the whole of the rock, the minerals being arranged roughly in parallel bands, the pale-green bands with predominant serpentine, the darker bands with predominant colourless pyroxene. Thin opaque bands traverse the section and probably represent portions of the original shaly groundmass. The pyroxene occurs almost entirely with small granular habit. Since the rocks shade off into more normal hornfels, they undoubtedly represent original argillaceous rocks which have been metamorphosed under the influence of intrusive sheets with a profound alteration in composition. The term "*injected hornfels*" has been used for such abnormal rocks, which moreover, correspond fairly closely to analagous occurrences in the Magaliesberg Series from Eastern Sekukuniland.

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* Annual Report Geological Survey for 1909, p. 65.

SECTION ACROSS THE VALLEY OF THE LYDENBURG DORP RIVER, SHOWING THE HORIZON OF THE ALTERED LIMESTONE.

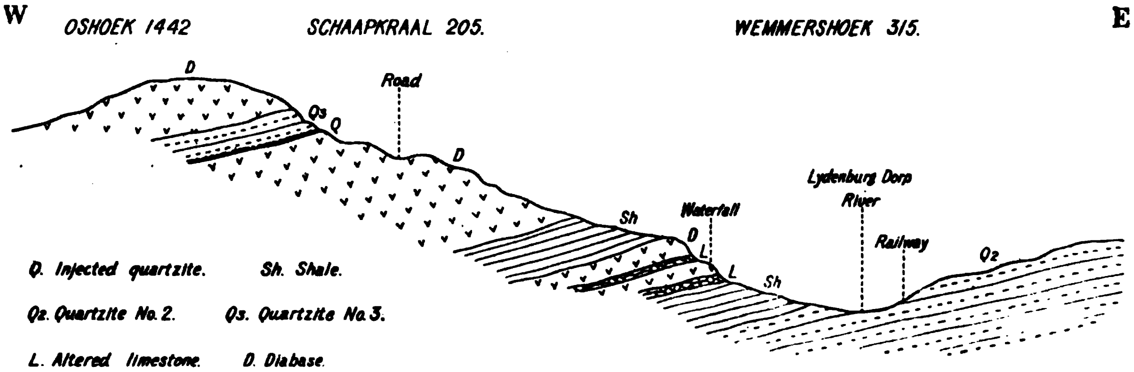

Fig. 2.

(*c*) *Altered Calcareous Rocks.*—On the farm Wemmershoek No. 315, west of the Belfast-Lydenburg Railway calcareous rocks were found conformably interbedded with altered shales. The best outcrop occurs in the bed of the stream which joins the Lydenburg Dorp River from the west, and about half a mile downstream from the homestead of S. Swarts. The horizon is between Magaliesberg quartzites Nos. 2 and 3, thus corresponding approximately to that of an analagous occurrence recorded from the area further north on the farm Bergfontein and described in the Annual Report of the Geological Survey for 1909.* The rocks form a very fine-grained nearly compact pale-green band about 10 feet thick, well exposed in smooth dip slopes in the bed of the stream a few yards above a little fall over an intrusive sheet. The exact horizon is indicated in Fig. 2, which also illustrates the position of the narrow band of injected hornfels at the base of No. 3 quartzite referred to above. The altered calcareous rocks occur in two bands separated by a thin intrusion, over which the fall takes place. The upper band has a thickness of some 10 feet and in it—exposed on the left bank of the stream—is found a thin quartzitic layer about 12 inches thick. Thin sections of the green rock indicate a serpentinized limestone. The general appearance in colour of this beautiful rock suggests its possible use as an ornamental stone, but it breaks very unsatisfactorily under the hammer, and it is doubtful whether anything more than small pieces could be procured in uniform size and quality. At several other places in the Lydenburg District similar calcareous rocks have now been located, and the occurrence on Wemmershoek answers in position and petrographical characters very closely to the serpentinized calcareous rocks noticed by Dr. Humphrey on the farm Bergendal a few miles north-west of Dalmanutha Siding, north of the Delagoa Bay Railway.

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* Annual Report Geological Survey for 1909, p. 67.

5. DOLOMITIC LIMESTONE.

On the high granitic plateau about two miles west of Sekukuni's Mountains occurs a remarkable outcrop of calcareous rocks, resembling the dolomite formation as regards general characters. The occurrence lies near the centre of the common boundary between the farms Eenzaam and Spitskop. The rock is surrounded on all sides by elaeolite-syenite which itself lies in the Bushveld granite.

The rocks are light greyish holocrystalline varieties with medium to coarse grained texture, weathering with a characteristic brownish black colour and rough pitted surface, in many respects recalling the dolomite formation of the Transvaal System. Thin sections show practically nothing but carbonates and a little serpentine, and suggest a calcareous rock subjected to thermal metamorphism. The relationship to the elaeolite syenite is not shown, neither are there any definite indications of dip. The rocks form thick, fresh, and somewhat rounded masses, which along the edge of the stream running near the common boundary reach the thickness of some 20 feet, but neither top nor bottom of the calcareous area is exposed. The occurrence of such dolomite rocks well within the granitic area of the Bushveld Complex is remarkable and not easy to account for. A definite corelation with the Dolomite formation cannot be maintained, in view of the absence of all stratigraphical evidence, but it is conceivable that this outcrop may be a fragment of the Transvaal System caught up in the magma of the Bushveld Complex. In the present case the fragment covers an area of about a quarter to half a square mile, and this is by no means excessive when compared with analagous expanses of very much larger masses of Pretoria Series caught up by the basic magma in the Marico District.

6. IGNEOUS ROCKS IN THE PRETORIA SERIES.

Within the present area, igneous rocks are widespread and conspicuous in the Pretoria Series. They fall into two sharply distinct groups, intrusive and contemporaneous.

Intrusive Rocks occur in the form of sheets or sills and are much in evidence round Dullstroom and along the Steenkampsbergen. Considerable areas both east and west of Dullstroom are covered by such rocks and their presence can be easily recognized in the scenery by the absence of linear features and the characteristic mode of weathering into spheroidal blocks having a deep brownish weathered surface. A typical example of this marked influence on the scenery is seen in the prominent kop known as Grootzuikerboschkop which makes a landmark about a mile north-east of Dullstroom Station. Here practically the whole thickness between quartzite Nos. 3 and 4 is made up of an intrusive sheet with a maximum width of nearly three miles and an approximate thickness of at least 1000 feet.

Another very persistent and well exposed sheet lies immediately below No. 3 quartzite in the upper part of the Lydenburg Dorp River Valley. It metamorphoses the base of the quartzite in the manner referred to above.

In petrographical characters there is a very close resemblance to analagous intrusions described from the northerly extension of the present area and form the Pretoria Series as developed in the central Transvaal. Pale to dark-greenish, medium-grained varieties predominate with plagioclase and augite as the commonest minerals. The latter may be more or less completely paramorphosed into hornblende (uralite). The occasional occurrence of slightly pleochroic rhombic pyroxene suggest affinities to norite. Very generally the sheets answer petrographically to diabases and gabbros, while in only one subordinate occurrence olivine was met with. Their character as intrusive sheets follows at once from the mode of distribution and contact alteration (see above).

Collectively these rocks represent the sheet or sill form of intrusion, as compared with the body of the norite, which consolidated in the laccolitic form, so that both are very probably derived from one parent magma. This is strongly supported by the following considerations. As one approaches the top of the Pretoria Series, i.e. the contact with the main body of the norite, intrusions become increasingly more numerous and thicker; this is well illustrated along an east and west traverse across Dullstroom, where shales above quartzite No. 3 are quite subordinate as compared with their predominance below No. 1 quartzite in the Badfontein Valley. In the second place an intrusive sheet is sometimes found passing without break into the main body of the norite. Finally, there is a very close general resemblance in petrographic characters between igneous rocks found as sheets and the extreme outer edge of the basic margin of the Bushveld Complex. These reasons leave little doubt as to the intimate connection between the two forms of intrusive bodies.

Contemporaneous Rocks are restricted to a well-defined horizon between the uppermost Magaliesberg quartzite and the edge of the norite. Hitherto such rocks have only been known from below the Daspoort Quartzite, both in the Lydenburg District and in the central Transvaal. During the survey of the present area a new development of volcanic rocks was discovered west of Dullstroom between the Pretoria Series and the main body of the norite. The rocks are very well seen on the main road leading from Dullstroom across Windhoek to Tonteldoos; much of the ground belonging to the farms Witpoort No. 26, Welgevonden No. 40, and Konterdanskloof No. 915 is also occupied by the same formation, which thus attains a considerable thickness and gives rise to a belt of hilly country, comparable in width to the Schurwebergen north of the Krugersdorp–Zeerust Railway, where the lower horizon of contemporaneous andesite below the Daspoort Quartzite is well represented.

The best section of these volcanic rocks west of Dullstroom is exposed along the Zwartspruit on the farms Konterdanskloof No. 915 and Witpoort No. 26, where they attain a width of nearly five miles, resting directly on the highest Magaliesberg quartzite, here represented by a thin extra band above the main No. 4 quartzite. The western limit against the norite is not well defined, but in places the junction runs along the higher slopes of the range of volcanic koppies, and in such cases the contrast between the smoother and more rounded outlines due to the contemporaneous formation, and the black rugged slopes strewn with large spheroidal blocks of norite, becomes very clear and the change can be readily followed in the scenery, e.g. over the eastern portion of Witpoort. Petrographically the volcanic rocks show a very striking resemblance to the lower horizon below the Daspoort Quartzite. They are fine-grained, dirty greenish rocks, full of white slightly elongated vesicles, generally of quartz, which stand out on the brownish weathered surfaces in characteristic knotlike excrescences. Such vesicles may be arranged in layers and may become drawn out in the manner common to lavas. No definite principle can be discovered regulating the distribution of the vesicular zones and there is, in fact, considerable variation in petrographic characters over quite short distances. Occasionally portions become more crystalline, showing abundant plagioclase in thin sections, approaching an acid labradorite in characters. The ferro-magnesian constituents are represented by hornblende. The vesicles are usually quartz, but occasionally they are filled by hornblende, e.g. along the common boundary of the farms Konterdanskloof and Welgevonden. There is little doubt that the above formation represents a contemporaneous volcanic flow or several flows. This view is strongly supported by the vesicular character of the rock, in which the quartz vesicles are frequently arranged in a kind of flow structure with markedly elongated vesicles. The absence of glass in thin sections is probably due to devitrification, as a result of thermal metamorphism from the intrusive norite. There is no genetic connection with the magma of the Bushveld Plutonic Complex, since the vesicular rocks occur interbedded with thin quartzites, and the distribution of the former has no analogy whatever with that of the intrusive sheets, derived from the norite magma. Furthermore, a little south of the centre of Witpoort rocks resembling the agglomerate associated with the vesicular andesite of the central Transvaal are found. Followed northwards along the strike, the volcanic horizon thins down and probably does not extend much beyond Houtenbeck No. 194, while towards the south there is a marked increase in thickness. The above described formation closely resembles the so-called Ongeluk Series of the Griquatown Beds of Cape Colony.* To the group of contemporaneous rocks probably also belongs the outcrop seen near the summit of "Kopje Alleen", an isolated and well-marked little hill close to the Badfontein Store on the west side of the Lydenburg–Machadodorp main road. The eastern slopes of this remarkable feature contain mainly soft yellowish gray shales. On the summit, at the remains of the blockhouse, blocks of a soft greenish probably intrusive rock are found, while on the south side a little below the top an outcrop occurs made up of angular fragments apparently of igneous origin in a quartzitic matrix. The last-named occurrence probably represents a volcanic agglomerate. But its relationship is very obscure. Several old prospecting works on the eastern slope reveal an apparently altered micaceous sandstone.

7. THE BUSHVELD PLUTONIC COMPLEX.

The rocks belonging to the igneous complex of the Bushveld are represented by a series ranging between wide limits as regards acidity, the more basic members being restricted to a zone in contact with the uppermost horizons of the Pretoria Series, while the more acid varieties are found further away from the Transvaal System.

These igneous rocks stretch from the Steenkampsbergen westwards as far as the survey has proceeded, and form the eastern end of the great mass of plutonic rocks extending across central Transvaal to the western border of the Province. The various rocks met with in the present area may be conveniently grouped into basic, intermediate, and acid groups.

(*a*) *The Basic* rocks of the Bushveld Complex are confined to the country between Sekukuni's Mountains and the Steenkampsbergen, where they form a belt some eighteen miles wide, embracing the Steelpoort River Valley and including the whole of Mapochs country (see map, Plate XI). The most usual type is a medium to coarse grained mottled greyish norite, weathering with brownish or sometimes black surfaces. This feature combined with a very common occurrence of large spheroidal blocks account for the characteristically rugged and sombre aspect of the koppies. An occasional tendency can be made out to assume linear features, while a parallel orientation of constituents may be noticeable in hand specimens. Such features depending on orientation follow naturally from the mode of origin of the Bushveld Complex as a stratified laccolite.

Between the Bothasberg on the south and the southern termination of Sekukuni's Mountains the belt of basic rocks extends westwards for some distance down the valley of the Bloed River, and the distribution of basic and granitic rocks strongly points to the former being arranged in form of a sheet which passes underneath the granite, so that the course of the boundary lines between these two types resembles that of a sedimentary formation having a low westerly dip.

In general petrographical characters the norite of the Steelpoort River Valley closely resembles that of the area further north or from the central Transvaal. Hypersthene gabbro is by far the commonest type found in the belt of basic rocks, but a number of other varieties, such as pyroxenite and magnetite rock are also represented. Magnetite deposits are much in evidence in Mapochs country, e.g. along the Zwartrand close to Roos Senekal, and at Feest Kop, a low isolated little kop situated close to the main road about a mile south-west of Roos Senekal. The latter feature consists entirely of magnetite with general characters identical with those from analagous deposits—below Magnet Heights—and described previously.† The deposits form long narrow bands or sheets rarely exceeding a few yards in thickness, but persistent over many miles and always arranged parallel to the strike of the Pretoria Series. The most prominent occurrence in the Steelpoort River Valley forms a distinct ridge-like feature known as the Zwartrand, close to Roos Senekal, whence the ron ore can be traced southward as far as the neighbourhood of Blinkwater, while towards the north the Zwartrand line of deposits runs as a more or less continuous feature at least as far as Magnet Heights, thus forming some forty miles of magnetite bearing country. Other bands were found on Steynsdrift, Buffelsvlei, Diepkloof, and elsewhere. On the latter farm, near the source of the Kruis River, the ore forms the conspicuous "Magneet Kop". On the farm Leeuwfontein, near the headwaters of the Kruis River, the norite contains irregular pockets of very coarse pegmatite, rich in flesh coloured felspar, while close to Galgkop, about five miles north of Roos Senekal, a vein of opaque calcite about 14 inches wide occurs in the norite. The mineral is apparently quite fresh and can be readily obtained in fair sized cleavage rhombs which, unfortunately, are not transparent enough for optical purposes. Economically the norite formation has not so far yielded anything of importance, though an isolated occurrence of gold was at one time worked close to the southern boundary of Mapochs country.

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* A. W. Rogers and A. L. du Toit, "An Introduction to the Geology of Cape Colony", London, 1909, pp. 99, etc.

† Annual Report Geological Survey for 1909, p. 70.

(*b*) The more *acid* members of the Bushveld Complex comprise mainly granites and granophyres, showing under certain conditions great individual variations. They are restricted to the area west of the Steelpoort River and extend from the higher slopes of Sekukuni's Mountains westwards across the high plateau of Pokwani for many miles towards Olifants River, and they cover a large area belonging to the northern Middelburg District. The relationship of the granitic rocks to the norite is probably intrusive, for masses of the former occur as narrow strips in the latter and are most probably apophyses connected underground with the main mass of the granite. Thus on Steynsdrift along the left bank of the Steelpoort River occurs a low ridge of finer-grained yellowish grey granite, forming a distinct feature along the left bank of the Steelpoort River (see Plate IX). This experience is strictly analagous to the relationships between the norite and the granite seen round Magnet Heights and discussed in the previous Annual Report.* Judging from the occasional occurrence of granitic rocks at other places along the Steelpoort River between Steynsdrift and Magnet Heights, the granitic apophyses probably form a more or less connected zone of outcrops. It may thus be concluded that the intrusion of the granitic portion of the Bushveld magma occurred somewhat later than that of the more basic partial magma, which consolidated as norite. Remembering the general principle that the basic belt forms an igneous sheet dipping at a low angle towards the west and underlying the granitic rocks, the distribution of the acid rocks between Sekukuni's Mountains and Bothasberg will be readily understood. Owing to the cutting down of the country between these two ranges, the higher formation, i.e. acid rocks occur as isolated circumdenuded outliers resting directly on the underlying norite. This is well illustrated by the well-marked Spitzkop, on which stands the common beacon of the farms Paardekloof No. 99, Blaauwbank No. 35, and Kafferskraal No. 62. The granite rocks here form a capping resting upon norite and the junction between the two types is fairly well seen on the slopes of the kop (see Fig. 4). The same explanation also holds good for the prominent koppie, marked by the extreme easterly beacon of Rooikraal No. 14 and separated from the main escarpment of the Tautesberg; on the other hand, the narrow tongue of granite shown on Leeuwfontein along the right bank of the Kruis River, suggests in its field relationship an apophysis analagous to the Steynsdrift occurrence referred to above. The same principle of the stratified laccolite accounts for the re-appearance of the acid rocks on the northern and eastern slopes of the Bothasberg, but here they are soon covered up by the felsites of the lower Waterberg System.

The commonest variety of the Bushveld granite is the familiar coarse-grained red rock, weathering into the well-known "ball-granite". It is confined to the high plateau west of Sekukuni's Mountains where it forms sandy rolling country not unlike high veld scenery in some respects. The area north of Paardekop is specially characteristic of this phase of granite, and the rocks are usually exposed in large bare hummucky forms separated from one another by considerable sandy tracts devoid of outcrops. In petrographical characters there is a very close resemblance to the usual types of coarse Bushveld granite, described repeatedly in previous Annual Reports.†

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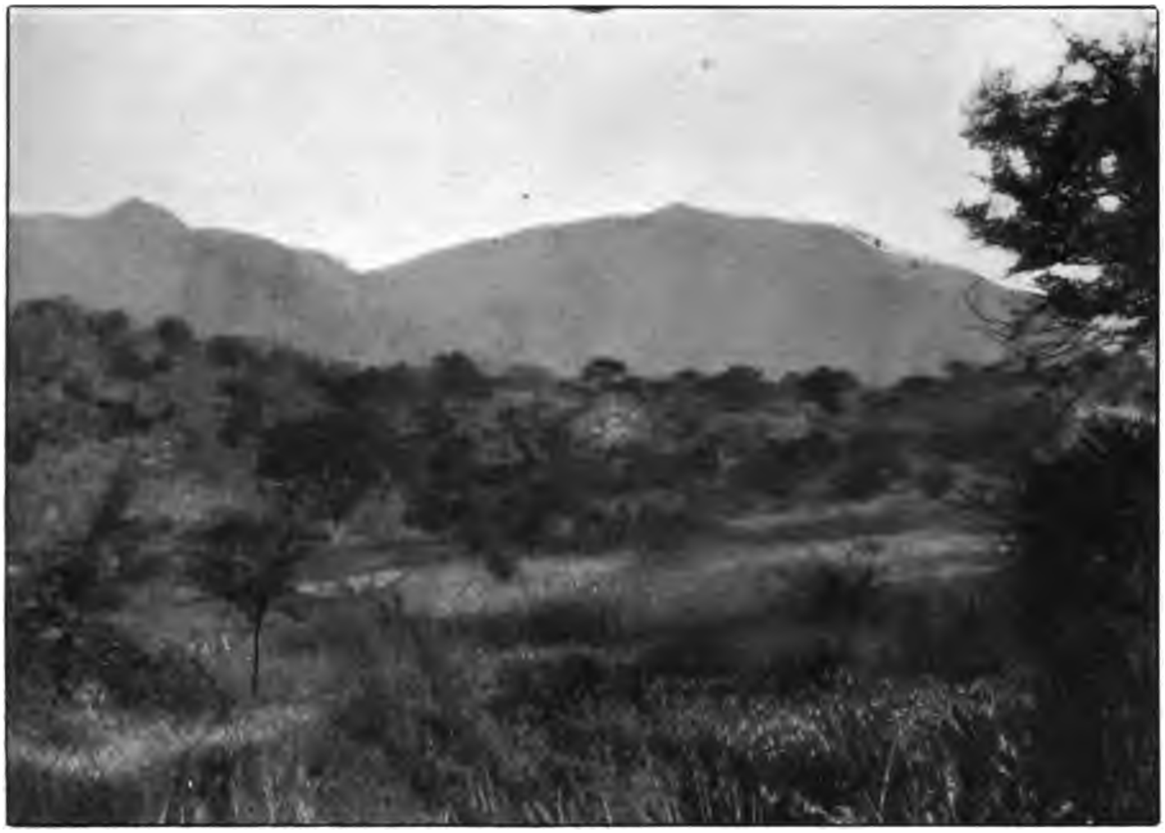
* Page 72.

† E.g. Annual Report for 1909, p. 71.



Sekukuni Mountains (Bushveld Granite). View looking westwards from the right bank of the Steelpoort River on Steynsdrift No. 16, Lydenburg District.

Lying close to the edge of Sekukuni's Mountains and extending north and south for some fifteen miles occurs an elongated mass of coarse granophyre, which forms an irregular belt of high ground lying on the general plateau and including Paardekop, the highest point west of Sekukuni's Mountains, also Vaalkop, another prominent kop situated a few miles west-north-west from Paardekop.

On the farm Goedgedacht, where the main road from Tautesberg to Pokwani crosses Diepkloofspruit a very sharp contact is displayed, showing the granophyre resting on the felsites, the contrast being readily seen in the changed character of the slopes, those due to the granophyre being strewn by large sub-circular blocks, while those due to felsite are much smoother and free from coarse debris.

It is thus probable that the granophyre represents an intrusive sheet later in age than the ordinary granite. In general characters it is almost identical with the granophyre seen along the Crocodile River north of Commando Nek.* Hand specimens show a medium to coarse grained texture, which varies from pale grey to reddish. The bulk of the rock consists of an intimate association of quartz and orthoclase with marked granophyric structure. Ferro-magnesian minerals are as a rule poorly represented and may be practically invisible in hand specimens (e.g. Vaalkop and Paardekop). A deep green hornblende is the ferro-magnesian constituent belonging to this group, found in very delicate needles or in small patchy masses.

GENERALIZED SECTION ACROSS THE VALLEY OF THE STEELPOORT RIVER ON STEYNSDRIFT No. 16, LYDENBURG DISTRICT.

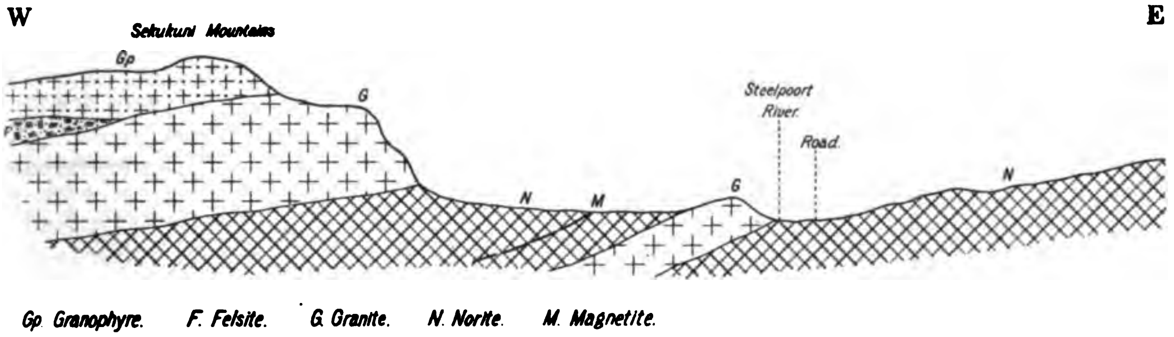


Fig. 3.

A remarkable group of rocks were found near the margin of the granite mass near its contact with the norite zone. They are very well exposed along the main road leading from the Tautesberg Police Post on Paardekloof to Pokwani, and occur as far north as the northern corner of Uitkyk No. 36. The same series may also be studied along the higher slopes of Sekukuni's Mountains, facing eastwards, e.g. Steynsdrift. They appear quite restricted to the edge of the granite and are collectively somewhat more basic in character. While along the escarpment of Sekukuni's Mountains these varieties form a band running parallel to the ridge, between Baviaansnek and the southern edge of Tauteshoogte they occupy a considerable area, since the field relationship strongly suggests that over the whole of the plateau above the Police Post the basic sheet of norite is overlain by a thin layer of the less acid granitic rocks, and as a result of the stratified arrangement of the major sub-divisions of the Bushveld Complex, the rocks occurring along the slopes of the Bothasberg are identical in character to the abnormal varieties situated above the Tautesberg Police

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* Annual Report for 1905, p. 74.

Post further north. Fig. 4 represents the relationship in diagrammatic form. Along the main road the following order is seen on proceeding northward from the Police Post. At the latter almost typical norite is found; a little way towards the north where the steep ascent to Tauteshoogte begins, a series of cuttings into the east side of the main road show a gradual transition into fine-grained dark coloured slightly porphyritic rocks weathering with a soft earthy rusty brown colour. The porphyritic constituents are small fairly plentiful phenocrysts of plagioclase, while the fine-grained matrix consists of much quartz and orthoclase with granular augite. The rocks may be provisionally termed quartz—augite—monzonite—porphyries, but there is much variation in detail, certain varieties becoming coarser in grain and approaching syenitic or dioritic phases. Still further up the hill and more especially on Uitkyk reddish fine-grained granophyric varieties come in, showing much intergrowth of quartz with orthoclase and small nests of hornblende. These finally pass into more normal medium-grained hornblende granites near Baviaansnek about three-quarters of a mile south of the Uitkyk fence. Identical sequences are observable along the main road leading from Blinkwater, past Stoffberg across the Bothasberg, while the finer-grained granophyric types are well seen in the Spitzkop outlier at the most southerly beacon of Paardekloof. On Steynsdrift, high up on the escarpment of Sekukuni's Mountains somewhat similar very fine-grained granitic selvage rocks are well exposed, and in turn pass into hornblende granite identical with that found on Uitkyk. It is probable that the above darker coloured finer-grained varieties represent a further differentiation product of the granitic magma resulting in a thin basal layer of less acid types, which in contact with a cooler floor of norite and other more basic rocks assumed a finer texture, thus answering to a kind of selvage phenomenon on a larger scale, the markedly closer grain possibly representing the result of more rapid cooling. The name suggested above indicates the presence of both plagioclase and orthoclase (either of which may occur as phenocrysts), while the prefix quartz refers to the groundmass showing a greater amount of quartz than is usual for common augite-monzonite.

GENERALIZED SECTION FROM TAUTESHOOGTE ACROSS THE BLOED RIVER VALLEY TO BOTHASBERG.

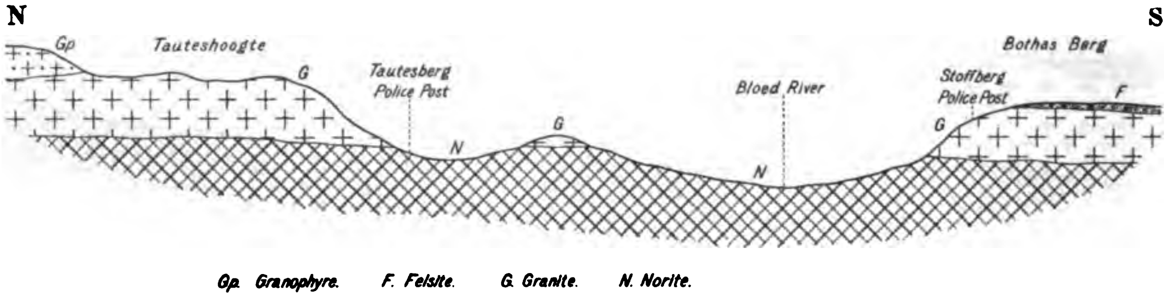

Fig. 4.

Intermediate rocks are represented by a single occurrence of *elæolite-syenite*, situated in the main body of the Bushveld granite, south-east of Pokwani, and five miles north-east of Paardekop, covering portions of the farms Rietfontein No. 451,* Spitskop No. 465, and Eenzaam No. 462. The mass of elæolite-syenite thus lies completely surrounded by granite not far from the edge of Sekukuni's Mountains; its surface extent amounts to about five square miles, most of which forms gently rolling country, but a little north of the centre of Spitzkop the syenite forms a distinct sharply pointed hill from which the farm derives its name. Similar less marked features due to the same rock lie on Eenzaam. While the true relationship to the red granite is not clear, the marked linear arrangement of minerals, and consequent pronounced banded structure along the western edge of the mass tend to show that the syenite is intrusive into and thus later than the granite, the direction of banding being generally strictly parallel to the line of contact.

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* H. A. Brouwer, "Oorsprong en samenstelling der Transvaalsche Nepheliensyenieten", Mouton & Co., Gravenhage, 1910, p. 172.

The great variation in petrographical characters so characteristic of elaeonite syenite masses is well exemplified in the present occurrence and the rocks vary considerably, but more especially along the western margin of the mass. The great majority of the rocks can be arranged into the following groups—*pyroxene foyaites* and *pyroxene foyaite porphyries*—*aegerine lujaurites,* both massive and schistose, free from eudialite—*elæolite aegerine pegmatites* and *urtites.* The first group embracing the *pyroxene foyaites* with or without porphyritic structures are best studied at the extreme westerly beacon of Eenzaam, about 300 yards east of the road shown on Plate XI leading from Swanepoel's homestead southwards. Round the well-marked corner beacon very fine outcrops of nepheline syenites occur. The rocks consist mainly of leucocratic greyish-white, coarse-grained varieties with large tabular anorthoclase up to one square inch in size ; where these are abundant and the ground mass finer-grained, the resulting type approaches a foyaite porphyry. The most remarkable feature at this outcrop is the linear arrangement of the anorthoclase, very well shown on weathered surfaces, the orientation being strictly parallel to the granite syenite contact. Such foyaite porphyries occur in bands from a few inches to several feet in width, which alternate with others consisting of greenish finer-grained varieties in which the potash felspar crystals are smaller, while the oriented constituents are represented by abundant delicate aegerine needles, arranged parallel to the tabular anorthoclases of the coarser variety. The latter, though usually greyish, is also often mottled reddish by predominant elaeolite showing the familiar waxy lustre of that mineral. Generally, coarser grain and more conspicuous potash felspar, go with more pronounced reddish colour of the rock. No sharp line can be drawn between the finer-grained greenish bands and the grayish red coarser foyaite porphyries, the whole mode of occurrence representing a primary phenomenon, due possibly to slight relative movements prior to consolidation. The marked orientation, combined with absence of further outcrops immediately east of the beacon, is strongly suggestive of a dyke, but more extended examination shows the banding to be a marginal phenomenon evidently pointing to a later intrusive relationship to the granite, which is well exposed close to some Kaffir huts west of the road referred to above. Proceeding northward from the Eenzaam beacon, another conspicuous outcrop of very coarse foyaite porphyry is found close to a small native location situated just within the farm Rietfontein, and about half-mile north of the most westerly beacon of Eenzaam. Here exceedingly coarse varieties of foyaite predominate.

In both localities, described above, one finds isolated occurrences of a very striking rock occurring in the foyaite and usually forming quite irregular masses or ill-defined bands from a few square inches to a few square feet in extent. They are conveniently referred to as *pyroxene foyaite pegmatites* or more accurately as aegerine elaeolite pegmatite. These striking types have a pronounced banded appearance due to alternate layers of reddish elaeolite and dark greenish black aegerine. The latter forms highly characteristic stellate aggregates composed of numerous very delicate aegerine needles. Such bands vary in width from half an inch downwards, and in places coarse potash felspar is associated with the elæolite. Thin sections of the pegmatite and foyaites proper show anorthoclase, nepheline (elæolite), aegerine, sphene, and apatite in order of abundance, while one rock, distinctly red in colour and containing only a relatively small amount of aegerine, showed a few small plates of deep brown biotite. The structure is hypidiomorphic and the banded character, so marked in hand specimens, is practically lost microscopically. Usually the nepheline is markedly idiomorphic and in the whole fairly fresh. The aegerine generally occurs plentifully in deep green strongly pleochroic needles or stouter columns with very low or nearly straight extinction. Sphene is a fairly constant accessory in good typical outlines. One variety of the pegmatite kind showed a fair amount of accessory apatite. From the above composition and structure the terms aegerine foyaite and aegerine foyaite porphyry would cover most types belonging to this phase. They are more predominant along the eastern and western edge, especially the latter, of the mass, and are quite subordinate in the more central portion.

A second group comprises the melanocratic massive and schistose ***aegerine lujaurites***, and represents finer-grained greenish varieties, very rich in aegerine, but without eudialite. Rocks of this character occupy a considerable portion of the mass and are well exposed, e.g. on Spitzkop over the south-western portion, notably south of the road, and elsewhere. In general appearance there is a marked difference compared with the foyaite group, especially in the predominant greener colour, much finer grain and trachytic to fluidal structures. Structures depending on orientation of constituent minerals become again more marked towards the margin, specially along the south-eastern edge of the mass, while towards the interior the rocks show no marked directional properties. Highly oriented varieties resemble hornblende schists in general appearance and split somewhat more easily along the planes of orientation. The weathered surface in the more massive lujaurites assumes a characteristic mottled and pitted appearance, the aegerine crystals standing out in small black knot-like excrescences and thus contrasting strongly with the yellowish brown areas due to decomposed nepheline. Thin sections contain the following minerals enumerated in approximate order of abundance : nepheline, aegerine, anorthoclase, sphene, and biotite—the last-named being quite subordinate and only represented in one section. On the whole the felspar is much reduced in amount, compared with the foyaite group, while sometimes both aegerine and aegerine augite are found. The structure is distinctly finer-grained and markedly trachytic in the schistose varieties, when the aegerine needles become oriented in a manner recalling fluidal structures. Aegerine augite tends to form large squarish plates, and is lighter in colour than the deep green aegerine, which occurs nearly always in long very slender needles. On the whole, the rocks here referred to as aegerine lujaurites answer, in general characters, fairly closely to the description given by Rosenbusch* of the lujaurites of Ramsay, which occur on the Kola Peninsula on the White Sea in northern Russia, with the exception that eudialite is wanting in the present occurrence.

With decrease of felspar, the above lujaurites pass into urtites, that is rocks composed almost entirely of nepheline and aegerine. Such extreme phases occur in the south-western corner of Eenzaam, but their exact relationship to the surrounding lujaurites are not exposed. They are evenly medium-grained dark greenish rocks, the reddish brown weathered crust being dotted over with knobs of aegerine augite, which weather more slowly. Thin sections show abundant nepheline and aegerine augite, both fresh, the latter in large somewhat pale green plates, the former in larger sections forming a coarse aggregate of allotriomorphic grains. Traces of apatite also occur. The rocks are comparable in general characters to the urtite of Ramsay, which forms extensive masses in the Kola Peninsula.†

(*c*) *Dyke Rocks* are quite subordinate. Associated with the elaeolite syenite intrusion described above, an interesting dyke was found near the southern boundary of Spitzkop close to the edge of Sekukuni's Mountains and a few yards from some Kaffir huts. It is about 20 feet wide and appears to emanate from the foyaite mass. The rock is greyish-brown and slightly porphyritic, through more conspicuous pale-reddish elaeolite ; thin sections show much aegerine, anorthoclase, and a little apatite. It is thus classed with the tinguaites. Other thin dykes were found in the norite and granite north of the Bloed River in fine-grained dark coloured varieties having no apparent connection with the syenite.

8. THE FELSITE OF THE LOWER WATERBERG SYSTEM.

These felsites are well developed in the Bothasberg, and on the granitic plateau west of Sekukuni's Mountains over the hydrographic basin of Diepkloof Spruit. Their presence is often easily noticeable in the scenery by the predominance of smooth contours free from large boulders. The felsite country, more specially in the last-named area, is characteristically dissected by deep kloofs, usually not noticeable until one approaches more closely. Surfaces underlain by felsite have only a very thin layer of soil, and are strewn with small somewhat angular fragments. Their relationship to the granites is the usual one over the Bothasberg area, the latter passing underneath the former. Along Diepkloof Spruit their junction with the overlying later granophyre intrusion runs up and down hill, so that the relationships are somewhat obscured. On Goedgedacht, both north and south of Diepkloof Spruit, very sharp junctions with the granophyre are exposed, and the felsite appears to lie between granite and granophyre (see Fig. 3).

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* H. Rosenbusch, "Elemente der Gesteinlehre", III Edit., 1910, p. 152 and fig. 27.

† W. Ramsay, "Das Nephelinsyenit Gebiet auf der Halbinsel Kola", II, Helsingfors, 1899.

Petrographically the felsite of the present area are identical with those found in the more typical localities in the Pretoria and Waterberg Districts. The rocks are similar in general character over wide areas, usually reddish or dark greyish-black incolour, with a fine-grained almost compact groundmass and small isolated porphyritic felspar crystals. On the Bothasberg amygdaloidal varieties with elongated and oriented quartz vesicles were found at one locality. For further details reference may be made to the description in previous Annual Reports.*

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* Annual Report for 1906.

IV.

THE GEOLOGY OF THE RUSTENBURG AND ZEERUST BUSHVELD

SOUTH OF THE DWARSBERG

By W. A. HUMPHREY (*Geologist*)

CONTENTS

1. AREA.

2. PHYSICAL FEATURES.
    (*a*) *Surface Relief.*
    (*b*) *Water Supply.*

3. GEOLOGY.
    (*a*) *Structure.*
    (*b*) *Formations.*

IV.—THE GEOLOGY OF THE RUSTENBURG AND ZEERUST BUSHVELD SOUTH OF THE DWARSBERG.

By W. A. HUMPHREY (*Geologist*).

I. AREA.

THE stretch of country to be described in the present report is situated immediately to the south of the Dwarsberg and includes the whole length of that range. It extends east and west across the Marico and Rustenburg Districts from the Bechuanaland Protectorate border as far as the foothills of the Pilandsberg. The Marico River flowing towards the north, and forming the approximate boundary between the Marico and Rustenburg Districts, divides the area into two portions. Of these the westerly, or Marico portion, consists of a comparatively narrow stretch of country lying immediately to the south of the Dwarsberg, and bounded on the south by the limits of the map completed in 1909 and published in the Report of the Geological Survey for that year. The more easterly extension of the area lying to the east of the Marico River and situated in the Rustenburg District includes a much larger tract of country and extends south to the Zwartruggens and the Elands River. It includes the Matlapynsberg, and its easterly boundary lies in the turf flats immediately to the west of the Pilandsberg.

On account of its inconvenient shape the area is represented in two maps (see Plates XII and XIII) one of which includes the Dwarsberg, and the strip of country lying immediately to the south of that range, which is geologically one continuous series, while the second includes the country lying to the east of the Marico River, and to the south of the Dwarsberg map.

The combined area covered by the two maps amounts to about 1820 square miles and includes 1710 miles of geological boundary lines.

The area is very scantily populated, nine-tenths of the white inhabitants living on the banks of the Marico and Elands Rivers, and on the slopes of the Matlapynsberg and Zwartruggens.

Water is exceedingly scarce except in the above-named localities, and along the slopes of the Dwarsberg, and the native population is not numerous. Considerable native stads exist at Mabieskraal No. 620, Pella, and small collections of huts are found wherever there is sufficient permanent water.

The main roads are good from Ramutsa to Zwartfontein, Vleeschfontein, and Brakfontein, and from Zeerust to Derdepoort, while good roads exist on both sides of the Marico River as far north as Koffykraal No. 619, after which that on the right bank of the river is the better. Good wagon roads also run from Rustenburg to Derdepoort through Bierkraal No. 545, and through Mabieskraal and Rampapaanspoort, also from Mabieskraal to Silikatskop. The remainder of the roads are only fair and are frequently lost in the black turf soil. In the southern portion of the eastern area good roads connect the inhabited portions.

2. PHYSICAL FEATURES.

(*a*) *Surface Relief.*

The outstanding topographical feature in the area is furnished by the mountainous range of the Dwarsberg which forms its northern boundary. This range extends from within a few miles of the western boundary of the Transvaal near Ramutsa for approximately sixty miles in an easterly direction, where it gradually loses its height and width and degenerates into a series of low intermittent ridges.

In its westerly extension in the Marico District it forms three well defined ranges representing geologically the three main quartzites of the Pretoria Series. The dip is fairly high, consequently the separate ranges are steep and rough and the intervening valleys of no great extent, but vary from about a mile and a half to four miles in width. As the range is followed to the east the most northerly and prominent of the three ridges ends somewhat abruptly on the farm Abjaterskop No. 152. It has laterally an extension of some sixteen miles throughout the whole of which its massive beds with their steep escarpment overlooking the country to the north form the principal feature of the neighbourhood. From this point however the middle ridge which is a double one and represents the quartzites of the Daspoort horizon increases in height and becomes more massive and imposing, and it is this range to which the name Dwarsberg is given over the forty odd miles where the lower of Timeball Hill Quartzites on the north make no topographical feature. This middle range has an unbroken extension from end to end of the Dwarsberg and with the exception of the sixteen miles at the western end it is the dominating feature of the range. The third and most southerly ridge of the range is well developed from the Transvaal border on the farm Buitenkuil No. 244 eastward to Onverwacht No. 142, after which it becomes less conspicuous and on Brakfontein No. 307 it dwindles to a series of steep kopjes, and gradually disappears as a topographical feature some miles west of the Marico River.

As the dip of the strata is towards the south the slopes of the mountains in that direction are not steep, but form a series of dip-slopes for the most part thickly covered with bush and timber, while the northern slopes are steep and capped by the almost perpendicular escarpments of the different quartzite horizons. The dip-slopes are cut up by numerous watercourses which render them occasionally extremely rough and rugged, and the main or Daspoort double ridge is especially so from the presence of a narrow lateral valley of varying depth which marks the shale horizon between the two quartzites. On the whole the Dwarsberg is very deficient in water, although considerable springs are found here and there along its length. South of the Dwarsberg in the Marico District a broad valley is followed, immediately to the west of the Marico River, by wide turf flats which extend southwards to the Enzelberg. Frequent flat topped or irregular kopjes stand out at intervals and occasional low ridges mark the direction of dykes and quartz veins which traverse the pyroxenite country rock. These flats give place towards the west to a series of fairly prominent ridges of sedimentary rocks, which extend from Brakfontein No. 307 in a south-westerly direction.

They form a broad sandy belt rising to the north-west and ending in a quartzite escarpment. These hills merge into the Zwartfontein hills described in a previous report.*

Along the western border of the Province a series of ridges representing a faulted portion of the Dwarsberg rocks gives place on the south to turf flats similar to those west of Marico River.

In the Rustenburg District a somewhat different distribution of geological horizons has produced a different type of scenery.

Here a thick series of altered shales overlying the Dwarsberg beds and intercalated with sheets of diabase and norite has occasioned a somewhat undulating type of country with no very marked features. Certain hard shale horizons form low but continuous east and west ridges as far south as Silikatskop No. 122 and the hills north of Mabieskraal No. 620.

Owing to the fact that the southern area of the Bushveld syncline was invaded by the norite, and that the upper Magaliesberg horizons of shale and quartzites were faulted away and separated from the rest of the Pretoria Series on the south by an intrusion of the norite, the Bushveld basin presents here quite a different aspect from the expanses of igneous rocks usually found which give a uniform and typical character to the scenery, The upper Magaliesberg beds are here broken into three distinct masses of shales with the quartzites normally overlying them and forming distinct mountain groups. Of these the most considerable is the Matlapynsberg, where the quartzite escarpment rises to a prominent peak on the farm Lemoenplaats No. 845. These mountains trend towards the north-east and cover an area of some fifty square miles. They overlook on all sides except the north expanses of turf soil formed from the disintegration of the intrusive norite and pyroxenite. Good springs rise in various places among the hills, and the farms included in this area carry a considerable white population and a large number of native villages.

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* Annual Report of the Geological Survey for 1909.

To the north-east of this group and separated from it by an expanse of turf soil is a smaller group of hills, through which the Bierspruit makes its way. They are composed principally of quartzite, and form a series of ridges rising out of the surrounding turf soil. The scenery is broken and pleasing, and the abundant water of the Bierspruit on this farm could well be better utilized than is at present the case.

The third group of hills trends from Silikatskop No. 122 across the Marico, and, extending in a series of wooded bults and ridges southward along its eastern bank, recrosses the river on the farm Uitkyk No. 277, and terminates abruptly on the farm Doornlaagte. It forms long ridges of sandy soil densely covered with trees, with an occasional prominent kopje. For the most part these are low and swelling and make little topographical impression. The soil is, however, sandy and the vegetation quite distinct from that found on the turf flats.

Between this group of hills and the Matlapynsberg are extensive flats of black turf soil, giving place over considerable areas to red sandy soil, which carries scattered patches of bush and a uniform park-like distribution of larger trees. These expanses of red soil mark patches of sedimentaries which have been surrounded by the igneous rocks. Lying to the south of this zone is a development of rough ridges with a general east and west trend. In parts they are thickly covered with bush and occasional bare strips are found. This ridgy and in general stony terrain represents the lower Magaliesberg shales in their normal position with intercalated sheets of diabase. The rocks belong to the southern portion of the great Bushveld syncline and pass normally down into the lower members of the Pretoria Series.

(*b*) *Water Supply and Drainage.*

The Great Marico River and its tributaries drain by far the greater part of the area, through which it flows in a general northerly direction, the tributaries having for the most part an east and west trend.

This river enters the terrain on the south with a considerable perennial flow of water, which is extensively used on the farms along its banks for the raising of winter crops. Below Koffykraal No. 619 the river degenerates into a series of long pools during the dry season which, however, keep fresh, and are doubtless fed from a subsurface flow of water in the river bed. Some of these pools are several hundred yards long and of considerable depth. None of the tributaries of the Great Marico has a permanent flow of water in this area. Here and there, however, water is found where dykes or impervious sedimentary rocks strike across the bed of a stream and wells have been dug in various parts.

The north-western corner of the area is bounded by the Notwani River, which drains a limited area. There is, however, permanent water only on Buitenkuil No. 244 and at Ramutsa. On the east of the area the drainage lines are south to the Elands River and north-west to the Bierspruit, both of which belong to the basin of the Crocodile River. The watershed between this river and the Marico River follows a line from Schoongezicht No. 416 (where the massive range of the Dwarsberg begins to become intermittent and gives place to a series of kopjes and short ridges) southward to the group of hills north-west of Mabieskraal No. 620 and the Matlapynsberg, and from thence to the Schurvebergen.

Extensive winter crops are grown along the banks of the Marico and Elands Rivers, and in the Matlapynsberg, while permanent water exists in addition on the following farms :—

Zeerust District :—Zwartfontein No. 184, Kalkfontein No. 42, Putsfontein No. 326, Hermanskraal No. 125, Brakfontein No. 307, Tweekopjesfontein No. 58, Witkleigat No. 273, Olifantsfontein No. 121.

Rustenburg District :—Witfontein No. 306, Okkerskraal No. 3, Gausvlei No. 111, Schoonkloof No. 138, Oud Thomas-zijn-loop No. 969, Elandsdoorns No. 647, Putsfontein No. 559, Mabieskraal No. 620, and Bierkraal No. 545.

Except in the three groups of hills formed by the Magaliesberg Quartzites abovementioned, there is no natural permanent water south of the Dwarsberg in the Rustenburg District, apart from the Marico River, until the foothills of the Schurvebergen are reached, along which runs the Rustenburg–Zeerust main road. Here and there pits and wells have been dug, and in some cases good water has been found. These localities are included in the above list of farms.

3. GEOLOGY.

(*a*) *Structure.*

In its broad outlines the geology of the area is simple, but its details are complicated and involved. The area in question comprises part of the westerly extremity of the great Bushveld Complex and the associated syncline of sedimentary formations belonging to the Transvaal System. Of these latter the Dwarsberg, along the northern edge of the area, is built up of rocks belonging to the Pretoria Series, while the Dolomite and Black Reef follow normally to the north. Along the southern edge of the syncline the igneous rocks of the Bushveld laccolite are also confined by rocks belonging to the Pretoria Series, but on this side, instead of having the usual succession of Pretoria Series horizons followed by the Bushveld igneous rocks, the uppermost of the Magaliesberg beds, comprising shales and the main quartzites, are not found overlying normally the Daspoort beds as they do west of the Marico River, and east of Onderstepoort, north-west of Rustenburg.

Thus roughly between the Marico River and the foothills of the Pilandsberg the Magaliesberg quartzites and upper shales are not found in their normal position, but crop out in a series of isolated groups of hills which in every case are surrounded by norites and pyroxenites. It is thus evident that while as a general rule the Bushveld laccolite is held roughly to have intruded itself between the Transvaal and the Waterberg Systems, bending the former into a huge saucerlike depression and doubtless breaking it up in the process and sending out intrusive sheets into both systems, the line of main intrusion was here below the Magaliesberg quartzites as well as above them. Consequently this horizon became detached from the main mass of the Pretoria Series, was broken up into three principal masses, and with the solidification of the igneous magma and its subsequent denudation was exposed as we now see it in the three groups of hills before referred to. That the floor of the laccolite over this area formed of the Pretoria Series was much broken up, is evident from the fact that isolated patches of highly metamorphosed shale are found over the whole area covered by the norites and pyroxenites, sometimes extending over a few feet, or forming a narrow horizon which dies out at each end in the igneous rock, at others taking up the role of country rock in place of the norite over large areas. The norite intrusion below the Magaliesberg quartzites runs from Straatsdrift No. 977 on the Marico River eastwards, until it joins the main mass of norite west of the Pilandsberg. All sedimentaries, whether quartzites or altered shales, which occur to the north of this norite band, probably belong to the upper Magaliesberg beds. The northern limit of the norite is the thick intrusion striking east from the farm Welgevonden No. 552 on the Marico River.

The structure of the Dwarsberg, as a whole, is not involved. At its western extremity however the range is abruptly cut off by a powerful fault or system of faults, and terminates against the comparatively undulating country occupied by the upper beds of the Dolomite formation. The main fault has a roughly north and south trend, and brings the Dwarsberg, consisting of rocks belonging to the Pretoria Series, up against the Dolomite, Black Reef, and the underlying Ventersdorp System. To the west of this fault and striking north-east-south-west is a second one whose outcrop joins that of Fault No. 1 on the farm Zwartkopfontein No. 328 almost at the point where the Dwarsberg proper terminates.

The outcrops of these two faults enclose a wedge shaped piece of country whose apex is at their intersection on the farm Zwartkopfontein No. 328, and which is composed of rocks belonging to the Ventersdorp System. Black Reef, Dolomite, and lower Pretoria Series. This wedge shaped mass of rocks represents the upthrown side of both the faults as both to the east of Fault No. 1 and to the west of Fault No. 2 the rocks abutting on the fault planes are of a higher geological horizon than those enclosed within them. These latter have been thrown into a double fold which is apparent in the outcrops of the Ventersdorp System, the Black Reef and the Dolomite.

The lower Pretoria Series horizons appear on the farms Buitenkuil No. 242, Ruitjesvlakte No. 240, and Witkleigat No. 273, these latter probably representing the main Timeball Hill quartzites.

The fact that the massive range formed by the Timeball Hill quartzites and shales ends abruptly on the farm Abjaterskop No. 152 and that the Magaliesberg quartzites also die away when followed to the east suggests a system of strike faulting along the Dwarsberg more particularly in view of the structure of the Witfontein Mountains* and their extension into the east of the Rustenburg District.†

A close examination, however, fails to disclose any such fault planes in this neighbourhood and probably these phenomena are merely due to changes of sedimentation, shales taking the place of quartzites as the beds are followed from west to east.

Dip-faults at Rampapaanspoort No. 710 and Schoongezicht No. 416 break the continuity of the range. In both cases the downthrown side is on the west of the fault. The displacement of the Rampapaanspoort fault is somewhat over 2000 feet, while that passing through Schoongezicht has a much smaller throw.

Of the three groups of hills formed by the detached and broken masses of shales and quartzites representing the uppermost Magaliesberg beds belonging to the southern area of the main syncline, the most considerable is that of which the Matlapynsberg forms a part. These beds are much folded, and will be described in greater detail in a subsequent paragraph. They are followed to the north by a smaller group, principally developed on the farm Bierkraal No. 545 and culminating in Janskop. This group is separated from the first by a wide expanse of pyroxenite and norite. The third group is exposed along the Marico River southwards from Silikatskop No. 122, and shows local folding with a general north and south axis. The westerly extremity of this group is the geological continuation of the Magaliesberg quartzites of the Enzelberg, which terminate on the fault plane some seven miles further to the south.

(*b*) *Geological Formations.*

The rocks occupying the area belong to the following formations in ascending order.

Sedimentary.

1.—Ventersdorp System.
2.—Transvaal System.
    Black Reef.
    Dolomite.
    Pretoria Series.

Igneous.

1.—Bushveld Igneous Complex.
    Norites and Pyroxenites.
    Diabase.
    Syenite.
2.—Amygdaloidal Andesite.

Sedimentary.

1. *Ventersdorp System.*

The rocks belonging to the Ventersdorp System to be described occupy a very limited area within the wedge of faulted rocks on Van Tondershoek No. 245, Lekkerlach No. 253, and Zwartkopfontein No. 328. They are exposed from underneath the closed anticline of Black Reef quartzites whose outcrops confine them on three sides, while on the east they abut upon the fault plane which separates them from rocks belonging to the Pretoria Series.

Outcrops over this area are exceedingly rare, but all that were found consisted of one type, namely, a dark reddish ferruginous rock resembling a devitrified lava, and which bears a close resemblance to similar rocks found among the Ventersdorp igneous rocks at Moilo's location, and at the junction of the Aapies and Crocodile Rivers. The soil formed from the weathering of this rock is bright reddish yellow and somewhat sandy, and is fairly closely overgrown with bush and trees. The rocks in thin section show a very finely divided aggregate of quartz and felspar, in which magnetite is common in patches; it is much stained by red iron oxide.

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* Holmes, Trans. S.A. Geol. Soc., Vol. VIII, p 1, "The Geology of a Part of the Rustenburg District".

† Annual Report for 1908, p. 103.

2. *Transvaal System.*

(*a*) Black Reef.
  Quartzites.
  Shales.
(*b*) Dolomite and Chert.
(*c*) Pretoria Series.
  Timeball Hill Beds.
  Daspoort Beds.
  Magaliesberg Beds.

(*a*) *Black Reef.*

The rocks belonging to the Black Reef Series appear only in the small portion of faulted rocks where the Ventersdorp felsites are found. They consist of quartzites with overlying shales, and form a chain of small kopjes sometimes connected with each other by a low ridge, at other times separated by a stretch of sandy soil in which no outcrops occur. The outcrops of this series form a rough arc, dipping to the circumference and being the remains of an anticline, of which the summit has been weathered away. A small outcrop occurs to the north of the main line and separated from it by a stretch of dolomite under which the quartzites dip. The Black Reef is thus represented as a double fold whose axis runs practically due east and west. The total length of outcrop barely exceeds 4 miles. The quartzites vary somewhat in colour and texture, the lower beds being black and dark brown, and showing occasional thin beds of conglomerate. The upper beds are lighter in colour, and give place to a thin series of blue black shales. The total thickness of the Black Reef Series as here exposed amounts to perhaps 60 feet. It is, however, somewhat disturbed and broken by local faults, which make the thickness appear to increase and diminish, and it is to this fact that the larger of the kopjes forming the chain owe their comparative prominence.

(*b*) *Dolomite and Chert.*

Rocks belonging to this series are found in two portions of the area. The main Dolomite formation lies immediately to the north of the Dwarsberg, and extends from east to west. It lies as a whole outside the limits of the present report. In the north-eastern corner of the area, however, the strike of the Transvaal System brings the Dolomite within the limits of the map. It consists for the most part of normal blue crystalline dolomite showing the characteristic brown weathering and corrugated surface. Locally it is much altered, and shows tremolite needles of over an inch in length. This is especially noticeable on the farm De Aard No. 437. The dolomite is traversed by six parallel dykes of syenite which strike from Goedehoop No. 438 almost due south-east in the direction of the Pilandsberg. The Dolomite shows no particular signs of alteration along the margins of the dykes, and where it shows metamorphic minerals they are uniformly distributed throughout the rock, sometimes over considerable areas.

The small faulted outcrop of dolomite on the farm Van Tondershoek No. 245 shows no signs of alteration. The upper beds of the Dolomite formation contain massive bands of chert and overlying the series is a distinctive horizon of chert breccia and conglomerate cemented in a very hard siliceous matrix. Good outcrops of this breccia can be seen on the main road running north and south through the farm Zwartkopfontein No. 328 along the right bank of the Notwani River. Here this rock forms a well-marked ridge, and is overlain by a thin deposit of shales belonging to the Pretoria Series. The top of the Dolomite must be taken as those beds immediately underlying this chert breccia.

(c) *Pretoria Series.*

Rocks belonging to the Pretoria Series are exposed all over the area. They fall into three groups:—

1. Those forming the northern rim of the Bushveld Syncline.
2. Those forming the southern rim of the Bushveld Syncline.
3. Isolated masses wholly surrounded by igneous rocks of the Bushveld Complex.

1. Of these three groups of rocks those along the northern boundary and forming the Dwarsberg are the most interesting, as hitherto very little has been known about them. They have been described by Holmes* and mentioned by Hatch†, but not examined in detail. Taking the range as a whole, the most striking feature from a geological point of view is the thinning out of the upper and lower quartzite horizons when followed eastward from the great fault which marks the westerly termination of the range. The name Dwarsberg itself is applied first to the massive range formed by the Timeball Hill Quartzites, which make up the main range from Zwartkopfontein No. 328 to Abjaterskop No. 152. Here this range dwindles away in the space of almost a mile, and the name is then applied to that range formed by the middle or Daspoort Quartzites, which at this point are separated from the northerly range by about a mile of intervening valley. This is a double range and becomes very massive from this point eastwards and continues with very little alteration until it reaches Rampapaans Poort. East of the fault which traverses this poort the range is still impressive, but seven miles further east it is broken up into a series of kopjes. This is probably due to the presence of numerous syenite dykes which begin to cut across the strike of the series from this point eastwards.

Timeball Hill Beds.—As the crest of the Dwarsberg was taken as the boundary of the area west of the Marico River, the most northerly range, consisting of the main Timeball Hill quartzites falls outside its limits with the exception of the dip-slope of quartzites and shale facing south. The shales underlying this quartzite are frequently exceedingly hard, and form the crest of the range in many places west of Abjaters Kop. When this is the case, the quartzites form a subsidiary ridge half-way down the dip-slope.

To the west of the Faults Nos. 1 and 2, the Timeball Hill beds fall within the limits of the area. On the farm Zwartkopfontein No. 328 the Dolomite is overlain by a band of chert breccia or conglomerate, which must be considered as the base of the Pretoria Series. Following this conglomerate is a small thickness of blue black ferruginous shales of moderate hardness which can be seen on the extreme south of the farm abutting on the fault plane. They are here disturbed, and show contrary dips owing to the proximity of the fault. They are followed by a horizon of quartzite with which is associated a chert conglomerate similar to that of the bottom of the series. The quartzites are black, ferruginous, and somewhat friable, passing into the normal white sugary type characteristic of the Pretoria Series.

Above this quartzite, which corresponds to the lower Timeball Hill quartzites south of Zeerust, is a very considerable thickness of well-bedded blue-black shale, which shows occasional chiastolite needles, though the metamorphism has not destroyed any of the shaly characteristics of the rock. These shales are well exposed on the farm Buitenkuil No. 244, where they occupy the steep slope immediately under the quartzite escarpment, and continue to crop out on the flats to the north-east. They weather in all shades of red and yellow, and are about a thousand feet in thickness.

The main Timeball Hill quartzites in this extreme westerly development of the Series are well exposed in the bed of the Notwani River, and are responsible for the existence of the only permanent water in the river bed for several miles in each direction. They consist of two black and somewhat ferruginous quartzite beds, each of some 20 feet in thickness, overlain by a white quartzite band some 15 feet thick, and are all exceedingly hard. They form the steep escarpment face which crowns the very considerable range through which the Notwani River cuts its way along the north-western boundary of the farm Buitenkuil No. 244, which is also the boundary between the Transvaal and the Bechuanaland Protectorate. The geological position of the quartzites which form the range of hills trending along the eastern boundary of the farm Buitenkuil No. 244 through the south-western corner of Van Tondershoek No. 245, and on to Ruitjesvlakte No. 240 is not easy to determine. They cap the prominent kopje where the range starts on the west, against Fault No. 2. The escarpment is very steep, and the base of the kopje and the lower slopes are composed of dolomite. This would point to their being the lower Timeball Hill quartzites corresponding to that which crops out on the downthrown side of the fault on Zwartkopfontein No. 328. They are, however, much more massive than those, and consist of three distinct beds similar to, but not so ferruginous as, the Upper quartzites on Buitenkuil No. 244, while the conglomerate band is not present. They undoubtedly overlie the Dolomite by about 100 feet only which is apparent along the entire length of the range until it is cut by Fault No. 1 on Ruitjesvlakte No. 240. No strike fault is to be found by which the lower quartzites and shales could be cut out, and the conclusion come to is that these rocks represent the lower Timeball Hill quartzites, that the conglomerate band is wanting, and that these quartzites vary very considerably in thickness over comparatively short distances. A good section of these beds can be seen in the poort on the south-western portion of Buitenkuil No. 244 through which the old road from Zwartfontein to Ramutsa passes.

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* Trans. S.A. Geol. Soc., Vol. VIII, p. 167.

† Trans. S.A. Geol. Soc., Vol. VII, p. 1.

On Buitenkuil No. 244 and trending roughly south through Witkleigat No. 273 is a series of quartzite ridges whose outcrop forms a rough crescent. They are separated from those just described by about 2 miles of sandy ground over which no outcrops are found. Their dip on Buitenkuil is to the south-west at an angle of 30 degrees. They are thus apparently higher beds in the same series as the others, and their north-western end rests on fault plane No. 2. They most probably represent the upper Timeball Hill quartzites, but the various beds are separated from each other by outcrops of diabase, and diabase underlies them along their southern extension on the farm Witkleigat. This diabase merges into the main norite mass to the south-east. A ridge of quartzite is also found cutting the eastern boundary of the farm. It is evident that this wedge-shaped mass of rocks, in addition to its displacement by Faults Nos. 1 and 2, has been very considerably modified in its upper beds by the intrusions of norite and diabase, and the difference between these uppermost quartzites and the normal upper Timeball Hill quartzites must be explained as the results of the igneous intrusions.

On the eastern edge of the map, between its boundary and the Rampapaan's Poort fault, the Timeball Hill beds are exposed over a comparatively flat stretch of country at the foot of the chert hills of the Upper Dolomite. The lowest bed of the Pretoria Series here is a hard black ferruginous shale, occasionally banded, and frequently merging into beds of white quartzite.

It makes no topographical feature in the area, although to the east it forms an increasingly prominent range of kopjes marking the Dolomite contact. A wide expanse of flat country occupied by shale lies to the south of this basal bed, where very few outcrops are to be found. Between two and three miles to the south intermittent outcrops of white quartzite are found which do not disturb the level of the plain and are all that is left of the massive range which forms the dominating feature of the Western Dwarsberg.

Daspoort Beds.—The Daspoort beds, more than any other portion of the Pretoria Series in the Dwarsberg, persist with more or less uniform characteristics from end to end of the range.

They consist of the following in ascending order :—

Shales.
Quartzite and Conglomerate.
Amygdaloidal Andesite.
Quartzite (sporadic).
Shale.
Quartzite (black and ferruginous).
Shale.
Quartzite (white).

The lowest shales, immediately overlying the upper Timeball Hill quartzites, are dark blue in colour, well bedded and somewhat altered. They show needles of chiastolite more or less uniformly, but sparsely, distributed through the rock. Over long distances no alteration can be seen, but this horizon was not examined east of Abjaters Kop. The shales are hard and silicious in places.

They are overlain by a band of quartzite containing beds of quartz conglomerate of a total thickness of perhaps 25 feet. The pebbles in the conglomerate are cherty and close-grained, and the matrix is hard and silicious. This bed is continuous from Middelrand No. 254 through Heimwehberg No. 255, and forms the base of the lava flow which succeeds. Both conglomerate and lava are almost identical with those found in the same horizon on the southern arm of the Bushveld Syncline in the Schurvebergen, and near Magaliesberg Station.

The lava is a basic flow of andesitic type, amygdaloidal along definite horizons and close-grained along others. The primary portion consist almost entirely of an aggregate of hornblende needles between which a base of another mineral resembling devitrified glass or saussuritized felspar is sometimes observed. This, however, eludes definite determination. The numerous amygdales consist of quartz with occasional zeolites.

In the western portion of the terrain as far as Abjaters Kop this amygdaloidal flow occupies the valley immediately to the north of the escarpment slope of the Daspoort Range, the shales separating it from the Daspoort quartzites being of considerable thickness. These, however, thin out when followed eastward of Abjaters Kop, and consequently the outcrops of the amygdaloid are found higher and higher up the slope of the hill until at the Marico River they are found within a short distance of the quartzite escarpment and occupy the whole of the slope. This continues to be the case along the eastern extension of the Dwarsberg, the escarpment slope being exceedingly rough and encumbered with massive boulders weathered out from this amygdaloidal flow.

To the east of Rampapaans Poort the amygdaloid becomes thicker and harder, and weathers out in huge buttress-shaped hills under the quartzite escarpment, and falling away in precipitous slopes where the amygdaloid gives place to the underlying shale beds.

The shales overlying the amygdaloid measure some 150 feet in thickness at the western end of the range, and are ferruginous, black, and friable. They can be well seen on the farm Middelrand No. 254, while further to the east they thin out, and only appear as a narrow band immediately underneath the quartzite escarpment.

Quartzites.—The Daspoort Quartzites consist of two main beds separated by shales. From the farm Koedoesrand No. 246 eastwards the range consists of a double chain separated by a high-lying dividing valley. The southern slopes of the hills are densely covered with bush, and the valley above mentioned is sometimes almost impenetrable, and always exceedingly rough. This range constitutes the Dwarsberg proper, being its principal and dominating feature over a distance of over 40 miles from Abjaters Kop eastwards. West of that point, although still massive and impressive, it is quite overshadowed by the more northerly range which is much higher and more imposing. Besides the thick bush and scrub, big trees grow on the sandy dip-slopes, and the secluded intervening depression is still the haunt of the koodoo.

The lowermost quartzite is very ferruginous and black, and merges into the underlying shales, which become gradually harder and more quartzitic as the bed is traced upwards. It can be well seen at many points along the range, notably on the farms Drogedal No. 256, in the Western Dwarsberg, and on Okkerskraal No. 4, along the roads which cross the range on those farms.

The shales which separate these black quartzites from the upper and lighter coloured ones are seldom exposed. They can be seen, however, on the farm Drogedal No. 256. They usually occupy a depression between the two quartzite ridges which varies in width from 50 to 250 yards. It is sometimes deeply carved by streams flowing parallel to the strike of the formations, while at other times it is very slightly denuded and reaches a height not much inferior to that of the two containing ridges.

The upper quartzite horizon consists of a somewhat coarse hard whitish rock of about 50 feet in thickness. West of the farm Koedoesrand No. 246 this quartzite was not observed as a separate horizon. Apparently it thins out and shales take its place.

Magaliesberg Beds, normal development.—The shales which overlie the Daspoort quartzites are not well exposed, except at wide intervals. On the farm Ruitjesvlakte No. 240, immediately to the east of Fault No. 1, and in a water-course not far distant from the overlying quartzites, are good exposures of a fine red, well-bedded shale, somewhat soft and of silky texture. Probably these outcrops are weathered, but no signs of any other type was found.

No other outcrops of this horizon were found until in the neighbourhood of the Marico River on the farm Koedoesfontein No. 385. Here a very different type of shale is met with, soft and friable, black in colour, micaceous and graphitic in composition. This rock produces a black soil almost destitute of vegetation. It is almost identical with the graphitic shales found in the same horizon on the southern arm of the syncline at Zamenkomst No. 88 on the Marico River, 35 miles to the south.

On the same farm, viz., Koedoesfontein No. 385, the beds overlying these micaceous and graphitic shales have been much altered, and show no signs of their original shaly character. They vary from a rock in which cordierite in large platy crystals is the predominant mineral to others in which the biotite and quartz assume the major role, and the cordierite crystals, while still plentiful, are small. All the cordierite is crowded with inclusions. A similar type of rock is found on the farm Witfontein No. 306. East of the Marico River this lower shale horizon is generally obscured by the surface sand weathered out from the dip-slope of Daspoort quartzites which overlooks it on the north.

The Magaliesberg quartzites of the Dwarsberg form an imposing double range at its western extremity. They consist of a number of thin bands of quartzite, with thin shaly partings. A thick intrusion of diabase divides the quartzites into two well defined beds. They are more or less uniform in type, consisting for the most part of a hard white close-grained rock, graduating through yellow into brown. Standing on the summit of the escarpment at the north-westerly beacon of the farm Logaga No. 144, and looking north-east along the range, the various quartzites, some seven in all, with their shale partings can be easily followed. At the western boundary of the farm Welgevonden No. 241, the upper band of quartzites dies away, and the lower bed continues to the eastward with diminished topographical effect until to the north of Brakfontein No. 307 it degenerates into an intermittent chain of kopjes and ridges. The most easterly of these is on the farm Doornhoek No. 40, after which this horizon makes no noticeable topographical feature, although its outcrops can easily be followed over the Marico River. Its most easterly outcrop was found on the farm Kameelnek No. 654, after which the Magaliesberg beds consist of shales only in which several well-marked igneous intrusions are found. The structure of these upper beds along the Dwarsberg is peculiar. About 2 miles west of the Marico River a well-marked fault separates pyroxenites and norites on the west from Magaliesberg shales on the east. This fault line, which strikes due north and south, is marked by intermittent and sometimes massive quartz reefs, and against its eastern side the sedimentary beds end abruptly, while on the west pyroxenites and norite are developed. It passes to the east of Silikaats Kop and is lost in the development of norite lying to the south of it. It will thus be seen on an examination of the map that there are continuous outcrops of altered shales varied by interbedded sheets of igneous rock for a distance of some 10 miles to the south of the Magaliesberg quartzite horizon, on the farm Eerstepoort No. 25. These shales are almost invariably altered to crystalline cordierite rock, and the dip is seldom determinable. A certain number of dips were taken, however, and these with other indications support the view that the shales immediately overlying the uppermost quartzite are conformable, and that the sequence of beds of the Pretoria Series continues up to the norite intrusion, which strikes eastwards from the Marico River, on the farm Welgevonden No. 552. This would indicate that the Magaliesberg Beds of the Dwarsberg consist of a basal horizon of shales followed by quartzites and overlain by a great thickness of shales. The lower shales appear to be free from intrusions on the whole, with the exception of a small diabase sheet immediately to the west of Rampapaans Poort, while the upper shales are traversed by at least two persistent and well-defined sheets of igneous rock. The total thickness of these beds, counting the igneous sheets, cannot be far short of 5000 feet.

The upper shales vary in appearance and composition. All show signs of great alteration, and there are two distinct beds of hard quartzitic, well-bedded rocks, which vary between a flagstone and a quartzite. Of these two beds one forms a persistent ridge with occasional kopjes about half-way between the two igneous intrusions, and the other one lies above the upper intrusion, and some distance below the norite.

Along the southern arm of the Bushveld Syncline the Magaliesberg shales overlie the Daspoort beds and are traversed by numerous thick sheets of igneous rock. Immediately overlying the Daspoort quartzites is a thick intrusion which persists across the area.

This is followed by a band of black micaceous graphitic shale, which affords a characteristic black soil almost devoid of vegetation, and has been mentioned as occurring along the southern slopes of the Dwarsberg at the same geological horizon. In this band of graphitic shales, which are well bedded and show occasional needles of chiastolite are bands of crystalline cordierite rock, which evidently mark differences of chemical composition in the original shale beds as laid down. The overlying igneous intrusion is followed by a series of hard flagstones which form broken and rough country through the farms Vrede No. 656, Middelin No. 958, and Vlakte No. 305. The crystalline type of rock becomes more common and pronounced as these shales are followed northward, and the normal sequence of sedimentaries ceases along a line which is bounded by the intrusion of norite crossing the Marico River on the farm Staatsdrift No. 977 and extending eastwards until it merges in the expanse of norite and pyroxenite which flanks the western slopes of the Pilandsberg.

Magaliesberg Beds. Isolated patches.—The mapping of the altered shales, diabase, and norite to the north of this line and south of the norite intrusion which bounds the conformable sequence overlying the Dwarsberg, was a matter of great difficulty. These rocks crop out along no definite lines, the crystalline altered shale seldom affords an indication of dip and a great portion of the terrain is covered by black turf soil over which few outcrops are to be found. It is by no means safe to generalize and say that the expanses of black soil represent underlying norites and pyroxenites, because over very considerable areas where undoubted outcrops of continuous altered shale occur, the same black turf soil is found; and particularly, a very fine-grained glistening cordierite rock in this district invariably produces a black turf soil. Where the norites and pyroxenites become more acid, and diabasic rocks are widely distributed, the soil is generally reddish and somewhat sandy, and carries bush and trees. In the area north of Oud Thomas-zijnloop, and north-west of the Matlapynsberg the geological boundary lines have been drawn to include areas over which norite, diabase, or altered shale is the dominant rock. The areas marked norite or diabase both contain numerous sporadic outcrops of altered shale whose boundaries are quite impossible of representation, and the shale area also contains numerous intrusions, as shown by many isolated outcrops of diabase or norite. The whole of this central area consists of igneous rock intrusive in the shales, from which great masses have been broken off and surrounded by igneous material, and whose main body is full of intrusions. Some very interesting petrological specimens can be found among these altered shales and modified igneous rocks. Almost invariably a great deal of intensely pleochroic metamorphic biotite is found, while hypersthene and enstatite are common and sometimes very plentiful. Cordierite in some specimens makes up the bulk of the rock in large glistening crystals standing out on the weathered surface of the rock, to which it gives a knobby, irregular appearance. Immediately underlying the lower quartzite of the Matlapynsberg group is a characteristic metamorphosed shale which in the hand specimen could easily be mistaken for an igneous rock. Under the microscope it is seen to consist of a mosaic of quartz grains interspersed plentifully with brightly-polarising diopside and pleochroic hypersthene. Much metamorphic highly pleochroic biotite is present with occasional medium-sized crystals of cordierite. Large pink crystals of garnet are scattered throughout the rock (d. 629, 640).

A fine-grained black glistening rock consisting of small grains of felspar and cordierite has been mistaken in this district and in the Enzelberg for black quartzite. It is, however, undoubtedly a highly-metamorphosed shale.

In the neighbourhood of the large masses of sedimentary rocks surrounded by igneous material, where the Magaliesberg quartzites are found, the geological boundaries are much easier to follow.

The two main localities where these rocks occur are in the Matlapynsberg, and to the north and east of that prominent group of hills, and also along the course of the Marico River to the south-east of Silikats Kop, while a smaller development of them crops out on the farm Bierkraal No. 545. Here Jan's Kop is the most prominent of the hills formed by them.

These three isolated groups of hills represent the outcrops of the Magaliesberg quartzites between the Enzelberg on the west and the Pilandsberg on the east. They have been faulted far out of their original position, and each group is surrounded by igneous rocks of the Bushveld Plutonic Complex. The outcrop of which the Matlapynsberg forms a portion, has a general north and south trend, although much local folding has taken place. Along the whole of the eastern slopes of the hills the quartzites dip normally under the diabase and norite of the Bushveld Complex while westwards the beds have been thrown into a series of folds which usually end in an escarpment face, of which the Matlapynsberg itself along the eastern boundary of Lemoensplaats No. 845 is the most prominent. The fractured ends of these quartzites exposed on the farms Rietfontein No. 927 and Bultfontein No. 712 represent the continuation of the main horizon of Magaliesberg quartzites exposed normally some 10 miles to the eastward where this horizon abruptly ends. A line joining the ends of the fractured quartzites on the two abovenamed farms when produced eastwards joins them to the main normal development of this horizon. This is undoubtedly the line of fracture along which these beds found relief when invaded by the igneous rocks which now surround their isolated fragments. The structure is somewhat involved. The main "massif" of the Matlapynsberg consists of a thick mass of much altered shales, capped by a double band of quartzite which forms the summits. Good sections of the shales can be found on the western and southern ends of the mountain where the summit of the escarpment lies fully 1000 feet above the plain at its base. The shales consist of typical cordierite and andalusite rock, crystalline, and glistening. Under the microscope they show an even-grained aggregate of felspar and cordierite. Much metamorphic and highly pleochroic brown biotite is also present.

Towards the top of the altered shale series, and underlying the lowest quartzites is an interesting variation from the normal type of altered shales. It contains large garnets and is coarse-grained, simulating an igneous rock in the hand specimen. It has been described in a previous paragraph. This rock is found on this horizon through the whole of this group, of which the Matlapynsberg is the south-westerly extremity.

Following the quartzites from the Matlapynsberg escarpment, the dip continues to the east, but with a lessening angle, and eventually the direction is to the west. Thus a syncline is formed which also shows an escarpment to the east, though of not nearly so great an elevation or so impressive as that to the west. This syncline covers a distance of about 3½ miles from west to east, the quartzites cropping out over the whole stretch. A fairly flat valley follows to the east, lying at the foot of the escarpment of shales, and is occupied by diabasic rocks coterminous with the large development of igneous rocks to the south. This valley is about 4 miles in width and is bounded on the east by shales capped by quartzites dipping to the east under the diabase and norite of Bultfontein No. 712. Thus the sedimentaries here form a double fold, of which the syncline forms the Matlapynsberg and the anticline is weathered exposing the underlying igneous rocks of the Bushveld Plutonic Complex.

On the farms Holfontein No. 667, Syferfontein No. 625, and on the south of Mabieskraal No. 620, this double fold receives a twist with the result that the strike changes to north-west–south-east, while a local fault has disconnected the outcrops from the main mass of the Matlapynsberg and Bultfontein. The axis of folding here coincides with the direction of strike, and two double folds have been developed, of which the quartzite syncline forming the mass of the hill occupying almost the centre of the farm Holfontein No. 667, corresponds with the syncline of the Matlapynsberg. The crests of both anticlines are denuded, having been weathered down into valleys of altered shale and diabase, whose sides are formed by the steep escarpments formed of the overlying quartzites. Both the eastern and western extremities of this fold have disappeared, leaving a length of some 2 miles measured along the axes of the folds to join up the Matlapynsberg with the Mabies Kraal quartzite. These latter are formed of the same altered shales and quartzites as the others, and represent the north-easterly arm of the second anticline. They form a conspicuous range trending through the farms Mabieskraal No. 620, Tambootiesrand No. 86, and Klippan No. 311. Along the southern boundary of Elandsdoorns No. 547 and Tambootiesrand No. 186 is a range formed of quartzites and shales dipping to the south, while the eastern borders of the former farm are occupied by outliers of the same rock, due to flattening of the dip. Here and there minor faulting and folding have taken place locally, but the broad outlines of the geology are quite distinct. The range along the southern boundaries of Elandsdoorns No. 547 and Tambootiesrand No. 186 does not belong to the general system of folding which has produced the rest of the ridges of the group, as its dip is to the south. Its original position may possibly have been an extension of the ridge occupying the south-western corner of the farm Mabieskraal No. 620.

The second development of quartzites trends from Silikats Kop No. 122 and Nooitgedacht No. 35 southwards along the right bank of the Great Marico River. The topographical features induced by these rocks bear no comparison to the massive mountains and high ridges of the Matlapynsberg group. Silikats Kop itself, situated on the western bank of the Great Marico River, rises to a height of some 400 feet above the river. It is formed of altered shales capped by quartzites. These are disposed in the form of an anticline whose axis trends north 30 degrees east—south 30 degrees west. The crest of the anticline is unweathered and gives to Silikats Kop and also to Little Silikats Kop on Rooikoppiesfontein No. 125 their characteristic elongated dome shape. The shales of which good outcrops occur along the bed of the Springboklaagte Spruit are of the crystalline cordierite hornfels type, and consist of a fine groundmass of felspar, in which are flakes of intensely pleochroic biotite, large crystals of garnet, full of inclusions, and simply twinned crystals of cordierite with inclusions showing pleochroic haloes (d, 580).

The north and south fault (No. 3), mentioned before, bounds these sedimentaries on the east, and from the eastern side of the fault plane further south a bed of quartzite strikes eastwards across the Marico River, while an outcrop of flat-lying quartzite lies a mile to the north of it, surrounded by diabase. To the east of the Marico River, on the farm Nooitgedacht No. 35, these quartzites form a broad bush-covered sandy bult, striking north and south. The beds here are disposed as an anticline with the axis of folding trending in a north and south direction. Further to the south on the farm Misgund No. 54, an anticlinal structure is again to be noticed, the contrary dips being well seen on the summit of the bush-clad hill which overlooks the main road and lying to the south of Great Brak Spruit. On the farm Goedgevonden No. 843 can be seen a series of quartzite ridges trending roughly north-east and south-west, which cross the Great Brak Spruit. All these ridges, which dip west and north-west, strike in a north-easterly direction, and come to an end in the development of pyroxenite and norite which cover the farms lying immediately in that direction. To the south-west they cease to afford outcrops when traced away from the Great Brak Spruit, and form a sandy stretch of country which rises in a bushy bult. The actual boundaries of this horizon against the surrounding diabase are impossible of exact determination. These quartzites crop out again as the ground slopes to the Marico River, and here the dip is always to the north-west, the anticlinal structure not being met with again. This horizon shows outcrops along the alluvium bordering the Marico River which it crosses at the great bend where it is joined by the Toelanie River. On the western bank of the Marico the ridges are well defined and form a high bult which trends a little south of west until on the slopes to the east of Springboklaagte the outcrops are cut off against the pyroxenite by a fault. Along the edge of this fault the rocks have been bent and strike almost parallel to the fault plane, local folding being also apparent. The quartzites on Mayers Kraal No. 38 belong to this series. The fault plane which cuts off this series is continued to the southward. It marks the western boundary of the fractured portion of the Magaliesberg quartzites and shales due to the intrusion beneath them of norite and pyroxenites. West of this fault plane these quartzites, starting as low ridges unite to form the massive Enzelberg and continue in their normal position westwards to the border of the Province. The fault decreases in throw when followed southwards and disappears in the neighbourhood of the Daspoort Beds.

The structure of this group of sedimentaries has been described as representing*: " A great anticlinal fold in the Pretoria Beds with a north and south axis accompanied by minor foldings along the same line, the whole narrowing and dying away in a northward direction." This would seem to imply that the southern portion of the anticline widened out, its two arms joining with normal portions of the Pretoria Series developed to the east and west of the Marico River; the sedimentaries thus forming a tongue extending down the Marico River from the main development of the Series owing to the presence of the great anticlinal fold above mentioned. This reading of the geology has also been adopted in the more recently published maps of the district.

There is, however, in fact, no connection on the south between these sedimentaries, which represent Magaliesberg beds, and the Enzelberg quartzites, which are cut off by a fault before reaching the Marico River, while on the east bank of the Marico River no Magaliesberg quartzites exist in the normal position with which these could join up. They are in fact a faulted fragment of which the geological continuation is found on the west in the farm Zamenkomst No. 88, and from which their outcrops are separated by a distance of some seven miles measured along the fault-plane. On the eastern bank of the Marico River there are no Magaliesberg quartzites of any kind in normal position into which the eastern arm of this supposed anticline could merge, the whole of the upper Magaliesberg beds being broken up, and the nearest outcrops of the quartzites in the Matlapynsberg being some 19 miles to the east of the Marico River and 16 miles from the nearest outcrop of the Silikats Kop quartzites.

The position of these quartzites in the Marico River Valley is due wholly to faulting brought about by the intrusion of the Bushveld Igneous Complex.

Igneous Rocks.

The Bushveld Igneous Complex.

Norites and Pyroxenites.—These two rocks cover a considerable portion of the area. They are so intimately associated that it was not found feasible to map them separately, the one graduating into the other through numberless intermediate types, or changing within a few yards. They will thus be described together as basic igneous rocks. By far the greater portion of the country occupied by these rocks is characterized by the presence of black friable soil which supports a very scanty vegetation of grass. The soil on becoming dry, contracts, and huge cracks are developed, sometimes of considerable depth, and having a width of several inches. The roads over this soil are very good in winter if sufficiently used. The soil packs hard and firm and the roads are not heavy or particularly dusty. After heavy and continued rains, however, this type of country becomes one huge bog over which no transport is possible. This type of soil in this area is invariably found where the underlying rocks are norite or pyroxenite; but it is not in itself a sure indication of their presence in default of outcrops. Exactly the same soil is found where the very fine-grained, black, glistening cordierite rock (highly metamorphosed shale) is developed, and also on many of the river valleys where it must be considered an alluvium.

The norites are usually rich in pyroxenes, hypersthene being always present, and diallage and enstatite are common. Biotite occurs occasionally, while the felspar is basic, usually labradorite or its near equivalent. The pyroxenites vary from almost pure hypersthenite to rocks containing hypersthene, enstatite, diallage, and augite in varying quantities. The more basic igneous rocks are seldom found cropping out in the neighbourhood of the sedimentary masses, the latter usually being surrounded by less basic diabase. Exceptions to this rule occur especially along the Marico River on the farms Uitkyk No. 277 and Pagskraal No. 137, and occasionally when the mass of the sedimentary rock is small. On the farm Davidskuil No. 42 are small outliers of quartzite entirely surrounded by norite, while on Leeuwkop No. 26 and Goedgevonden No. 643 the ends of the quartzite strike into norite. On Misgund No. 34 pyroxenite is found between two horizons of quartzite.

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* Holmes, "The Pretoria Series in the Marico District", Trans. S.A. Geol. Soc., Vol. VIII, p. 173.

The field relationships of these igneous rocks in contact with the main sedimentaries, as also with the isolated masses whose outcrops are entirely surrounded by those of igneous rock, suggests that at the time of the intrusion of the laccolite, and the breaking up of the Magaliesberg beds into isolated fragments, the constitution of the magma was of intermediate character, and that the difference in temperature between the igneous rock and the surrounding sedimentaries and consequent cooling round the edge of the basin was sufficient to bring about the solidification of the extreme periphery of the igneous mass while the main mass of the laccolite still remained in the fluid state, and before differentiation took place within it, separating the more basic norites and pyroxenites from the granites and granophyres. Thus it comes about that around the extreme edge of the Bushveld Plutonic Complex, as also immediately surrounding any considerable masses of enclosed sedimentary fragments, a diabasic rock is found in which the felspars usually belong to the oligoclase-andesine class. Hornblende is the principal ferro-magnesian mineral, with occasional pyroxenes and mica, and the structure distinctly diabasic as opposed to gabbroidal. The intrusions in the Transvaal System consisting of sheets lying parallel to the bedding planes of the sedimentaries are usually of this type, and probably belong to the early period. In this area, owing to the fact that as a result of denudation the basin is very shallow, only the marginal basic phases of the igneous complex remain. The width of the outcrop of igneous rocks being here inconsiderable in comparison with their much greater development further to the east, it is very probable that the whole mass was composed of basic rocks at this extremity of its development. On the farm De Brak No. 276, aplitic veins traverse the country rock representing a later phase of intrusive activity. The rock on De Brak consists of large grains of quartz and weathered felspar with chlorite in well-defined crystals, pseudomorphs probably after mica.

Nepheline Syenite.—In the north-eastern portion of the area igneous dykes cut the formations. They strike parallel to one another, with a south-east and north-westerly trend. They are well exposed in the hills on Goedehoop No. 438, the igneous dykes generally cropping out along the crests of the ridges which they invariably form in the areas covered by Dolomite owing to their superior hardness. On passing out of the Dolomite into the Pretoria Series they furnish no outcrops, but can be seen on the farm Roedebloom No. 466, where they approach the quartzites. In the neighbourhood of Bierkraal they are again well exposed where the country rock is pyroxenite.

The dykes vary somewhat in composition. The most general type is an elaeolite-syenite in which the weathered nepheline makes up the bulk of the rock. The rock is porphyritic with large crystals of an orthoclase and nepheline. The groundmass consists of elaeolite needles with allotriotriomorphic felspar. Aegerine and aegerine-augite are plentiful in laths and tabular crystals. Zonar intergrowths of augite and aegerine are seen while reddish-brown biotite is common. Sodalite crystals full of enclosures of nepheline and aegerine occur sparingly, while apatite is common, and sphene is seen in occasional grains.

The dyke crossing the north-eastern corner of the farm Goedehoop No. 438 varies from the above type in the absence of elaeolite laths. Here the rock consists chiefly of felspar which occurs in laths and in squat crystals. Aegerine is common, sometimes surrounding augite. The groundmass is much weathered, and consists principally of zeolites which may originally have been nepheline. Apatite and sphene occur as accessories, while sodalite and biotite are common. This rock might be termed a soda-syenite.

V.

THE TRANSVAAL SYSTEM WEST OF THE KLIP RIVER VALLEY

BY W. A. HUMPHREY (*Geologist*)

CONTENTS

1. AREA.

2. TOPOGRAPHY.

   Physical Features.

   Drainage.

3. GEOLOGY.

   Structure.

   Formations.

V.—THE TRANSVAAL SYSTEM WEST OF THE KLIP RIVER VALLEY.

By W. A. Humphrey (*Geologist*).

1. Area.

The area to be described in the following report is situated roughly around the point of junction of the Krugersdorp, Heidelberg, and Potchefstroom Districts and comprises portions of each. It forms the westerly continuation of the work completed in 1909 along the course of the Klip River and comprises an area of 350 square miles, and includes geological boundary lines measuring 380 miles.

2. Topography.

Physical Features.

As the area in question consists principally of rocks belonging to the Pretoria Series, the topography is dominated by the ranges formed by the quartzite horizons, and a " Banken " type of scenery is produced. This is, however, considerably modified by the fact that the beds are disposed in the form of a rough syncline and that they are traversed by a parallel system of strike faults, by which the same horizons have been repeated.

The area is roughly bounded on the north and east by the range of hills which forms the easterly prolongation of the Gatsrand. It shows a well-defined escarpment to the north, and trends from west to east until, on the farm Allewynspoort No. 249, the strike changes and the ridge continues in a southerly direction, afterwards trending to the south-west. It is for the most part bare of trees, although occasional patches of bush are found under the escarpment. The dip slope is bare, and descends to a shallow valley running parallel to the range. In the north-eastern corner, where the synclinal structure is pronounced, this shale valley is followed by a rugged mass of hills which rises steeply on its southern side. These hills are formed of the amygdaloidal andesite which occurs in this geological horizon wherever the rocks of the Pretoria Series are developed in the Transvaal. On the farm Harzenbergfontein No. 132 it forms high and rugged hills, which are continued on Roodepoort No. 232, the intervening valley being eroded through the igneous rock laying bare the underlying sedimentaries.

A second range of hills parallel to those first mentioned extends to the south of them, and trends due east and west through the terrain. This ridge, like the former, is formed by the quartzites of the Timeball Hill horizon. They cease to form a prominent topographical feature east of Ennerdale South. Lying to the south of this range of hills is a stretch of undulating country, varying in width from two miles in the west to eight miles where it is crossed by the railway between Ennerdale South and Evaton Stations. Occasional rough lines of kopjes trending east and west break the undulating character of this belt. It is followed on the south by a low sandy ridge and wide shaly flats. On the whole, very little natural bush is found in this area, what little there is growing on the northerly slopes of the hills, under the quartzite escarpments. The rough kopjes of the amygdaloid are sometimes clothed with a scanty growth, while the valleys for the most part are quite bare. The whole area belongs to the High Veld.

Drainage.

The area includes the watershed between the tributaries of the Klip River, Mooi River, and Riet Spruit, and the general slope is to the south of the main range of hills formed by the more northerly Timeball Hill quartzites. Water is everywhere plentiful and most of the streams have a perennial flow. The tributaries of the Upper Klip River flow north, breaking through the main ridge, while those joining the river below its great bend flow east through the high ground.

3. GEOLOGY.

Structure.

The geological formations exposed in this area have been subject to a good deal of stress, which has found relief in certain definite directions, forming two systems of faulting. The more pronounced of these consists of the strike faults which traverse the terrain, roughly trending in a direction from north-west to south-east. By them the Timeball Hill beds are repeated in the easterly portion of the area. The dip faults are merely local and have no wide-reaching effect.

The main strike fault which has had the greatest effect on the geology starts on the farm Elandsfontein No. 493, some eight miles to the south-east of Bank Station. Its outcrop runs in a general south-easterly direction, as will be seen on reference to the map (Plate XIV). It can be traced as far as Varkensfontein No. 319 to the north-west of Meyerton Station, a distance of some twenty-four miles. It will be referred to as Fault No. 1.

SECTIONS AB AND CD ON MAP, PLATE XIV, ILLUSTRATING THE FOLDING AND FAULTING DESCRIBED ON PAGES 84 AND 85.

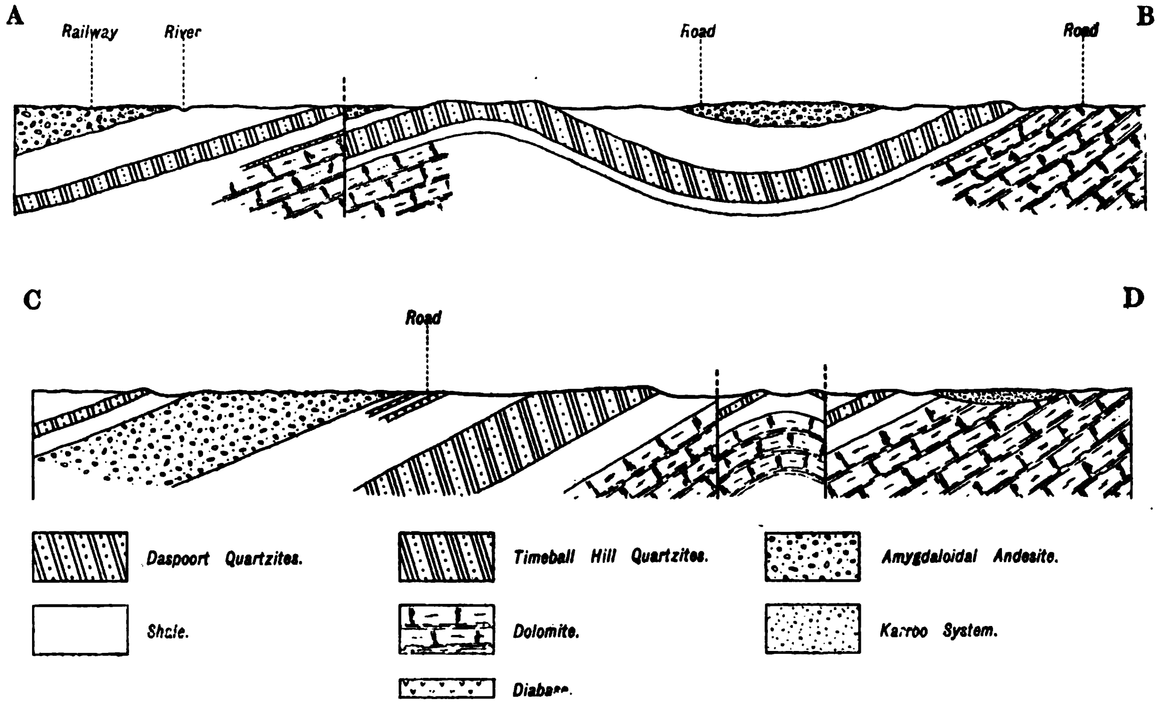

Fig. 5.

The downthrown side is to the north-east of the fault plane. The juxtaposition of rocks of different ages brought about by this fault varies somewhat along its length, owing to the presence of several local dip faults mentioned before. Thus on Modderfontein No. 362 we have Dolomite faulted into contact with Upper Timeball Hill Shales; on Hartebeestfontein No. 51 Lower Timeball Hill Shales abut against the amygdaloidal flow on opposite sides of the fault plane. To the south-west of this fault the sequence of the Pretoria Series is undisturbed so far as it was examined, the beds gradually decreasing in dip as the centre of the Losberg syncline is approached. The whole of the area thus forms the northern portion of the syncline whose axis runs through the Losberg, and whose southern arm has been described by Dr. Mellor.* To the north of Fault No. 1 a double fold has been developed, consisting of an anticline immediately to the north of the fault and a syncline which occupies the north-eastern corner of the terrain, and is also developed on the farm Elandsfontein No. 13, further to the west. Thus the north-eastern corner of the area consists of a syncline of Timeball Hill beds, covered by a massive outlier of amygdaloid which occupies the centre of the basin. (See Section AB.)

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* Report of Geological Survey for 1907, p. 23.

To the south-west it is followed by an anticline which brings up the quartzites over the space of some four square miles. These form a group of hills which, owing to the crest of the anticline being denuded, enclose a valley where the underlying shales are occasionally exposed over a few yards. To the south the quartzites dip normally under shales, and the ordinary sequence is found until the amygdaloid is abruptly cut off against the plane of Fault No. 1.

On the farm Elandsfontein No. 13 a similar structure is found, where a denuded anticline of quartzites is found occupying the space between Fault No. 1 on the south and Fault No. 2, which brings them in turn against Upper Timeball Hill Shales and amygdaloid. Fault No. 2, however, is not a true strike-fault, but its outcrop makes an angle of some 30 degrees with the strike of the series. Although the structure resembles that found further to the east, a portion of the fold has been removed by the denudation of the upthrow side of the fault plane.

A third fault traverses the Timeball Hill Quartzites and Shales on the farms Roodepoort No. 49 and Cyferfontein No. 190. The throw is very inconsiderable, but its influence can be seen on the south of the farm Elandsfontein No. 321, where it abuts against the quartzites of the anticlines. Here the dip of the quartzite beds over a short distance is reversed, and measures 80 degrees in a south-westerly direction. Possibly the fault may traverse this fold along its whole length and in a direction parallel to its axis, and be connected with the overthrust to be seen on the farm Witkop No. 66, which was described in a previous report.*

Of the dip faults the only ones which have any marked topographical influence are those on the farms Elandsfontein No. 493 and Doornpoort No. 407.

Formations.

The following formations are present in the area under review in ascending order :—

Sedimentary—
- Transvaal System.
  - Dolomite.
  - Pretoria Series.
    - Timeball Hill Beds.
    - Daspoort Beds.
- Karroo System.

Igneous—
- Diabase.
- Amygdaloidal Andesite.

Transvaal System.

Dolomite Series.

Rocks belonging to this formation cover the northern portion of the area. They occupy the southern slopes of the valley lying to the north of the Gatsrand. No outcrops of Dolomite are found to the south of the river, until one reaches the neighbourhood of the junction with the Pretoria Series, where it occurs on the slopes of the hills occupying the space between the numerous narrow bands of chert which here traverse the series. The chert stands out in hard resistant lines, and the Dolomite, being softer, has weathered and presents a scooped-out appearance between the chert layers. Outcrops of chert are much more numerous over the same area, forming rough low ridges or isolated patches. The soil is red and shows little of the chocolate brown tint so characteristic of dolomite soil, except in the lower portions of the valley in the neighbourhood of the river. The junction between this formation and the overlying Karroo rocks on Waterpan, Syferfontein No. 32, and Panvlakte No. 4 is very obscure, as outcrops on those farms are very scarce along the approximate line of junction. Occasional chert outcrops, however, mark the region of undoubted Dolomite and the end of the Karroo rocks. On the farm Modderfontein No. 362 is an isolated outcrop of dolomite and chert, which owes its presence to faulting. It is bounded on the north by the outcrop of the plane of No. 1 fault, while to the east and west it is separated from the Timeball Hill Quartzites and Shales by dip-faults. To the south the sequence is normal, the Dolomite being overlain by the Lower Timeball Hill Shales. This outcrop covers an area of some five square miles. The Dolomite is well exposed on the slopes of a high hill which occupies the centre of the outcrop, where its occurrence is the same as that of the main outcrop, namely, as depressed and weathered bands lying between thin beds of chert.

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* Report of the Geological Survey for 1909, p. 96.

Pretoria Series.

Timeball Hill Beds.—The greater portion of the area is covered by rocks belonging to these beds. The structure is complicated and has been treated of in a preceding paragraph, where it was shown that the Timeball Hill beds have been duplicated by a strike fault which traverses the area. Of these two distinct outcrops of the same beds, the more southerly is continuous to the west of the area mapped, and is succeeded conformably by the higher beds of the series, while the more northerly outcrop, which normally overlies the Dolomite, ends abruptly when followed to the west on the farm Orange Grove, apparently against Fault No. 1, while to the south-east of the area its easterly extension also ends against the same fault plane. Of the two outcrops that to the north will be described first. The lowest Timeball Hill Quartzites which are found on the farms Bronkhorstfontein No. 294 and Roodepoort No. 49, and which were described in a previous report,* are not well developed as the series is followed to the west. They afford outcrops on the farm Witkleigat No. 28 and Orange Grove and occasionally further west. They consist of white quartzites, with occasional bands of chert conglomerate, and usually immediately overlie the more or less massive chert beds which occupy the top of the Dolomite formation. The lower shales are blue and well bedded; when fresh exposures are to be seen, they are usually weathered near the surface and show yellow and buff tints.

The upper quartzites consist of four separate horizons, separated from each other by narrow bands of shale or diabase. Starting with the lowest, No. 1 is white to grey in colour, somewhat ferruginous, particularly in bands, and of close and even grain. No. 2 is usually red on the surface, although when unweathered it shows greenish colours. The upper portions are sandy and somewhat ferruginous, while the lower portions are usually white. No. 3 resembles No. 2, while No. 4 is similar to No. 1. The thicknesses are approximately 30 feet, 60 feet, 15 feet, and 15 feet respectively, while the various shale and diabase partings probably measure about 100 feet, taken together.

These quartzites crop out again on the farm Cyferfontein No. 191 in the form of an anticline whose axis trends roughly south-east and north-west. Possibly Fault No. 2 is continued along the northerly edge of these beds, as occasional high and reversed dips are met with immediately at the edge of the beds. Thus near the northern boundary of the farm and half-way between the two corner beacons the low north-easterly dip changes rapidly and becomes higher and higher, until after the beds standing on end over a few yards, they are reversed and dip to the south-west at an angle of 80 degrees, where the quartzite beds abruptly end. Elsewhere, however, the anticline is normal. On the farm Nooitgedacht No. 74 folding has again taken place, and this structure extends into the farm Varkensfontein No. 319. Here the quartzite escarpment normally overlooks the lower shales and Dolomite to the south-east. To the north-west, however, instead of the usual dip-slope, the quartzites form a small undulating plateau, and eventually dip almost due north, to reappear after a space of half a mile as a small sandy bult, formed of a quartzite anticline. They are here associated with an intrusive sheet of diabase.

On the farm Elandsfontein No. 13 these quartzites form a semicircular range of kopjes, ending in a conspicuous peak. The structure here is anticlinal, with a denuded crest laying bare the underlying shales. This anticline is cut by Fault No. 3, which has thrust up the south-western side of the fault plane, and so broken the continuity of the fold with the beds to the north. What must be considered as the main development of the Timeball Hill beds lies to the south-west of the Fault No. 1. All the portion to the north-east of this fault is cut off by it from the main development of the series, of which the south-westerly range is the true outcrop. It thus follows that the outcrops of the latter are continuous, while those of the former end against the main fault plane in opposite directions.

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* Annual Report of Geological Survey for 1909, p. 96.

The lower quartzite only rarely appears to the south-west of Fault No. 1, as the fault plane usually only traverses the shales, thus cutting out the lower beds. On the farm Elandsfontein No. 220 this horizon is exposed, also on Jachtfontein No. 99. The shales differ in no way from those of the more northerly outcrop. The Upper Quartzites form two well-defined and precipitous ridges in the west of the area, and from evidence gathered in the small area mapped it does not appear to be certain whether these two ranges represent the same beds repeated by a strike-fault or whether the shale beds separating No. 3 Quartzite from No. 2 Quartzite increase in thickness to the west, thus dividing the quartzites into two ranges and themselves occupying the intervening valley. This doubtful portion only extends from the western boundary of the area through the farm Leeuwpoort No. 526 and just over the western boundary of Doornkloof No. 155. Here the continuity of the beds is broken by a small dip-fault, on the eastern side of which the geology is clearer, and shows that the main quartzite is broken by an intrusion of diabase. Repeated dip-faults cut the beds when followed eastwards, those on the farm Elandsfontein No. 493 displacing the outcrops of the quartzite, and thus also the range for some two miles to the north. The quartzites continue to be massive and build up a considerable range as far as the farm Hartebeestfontein No. 51, where Fault No. 1 strikes more to the south. From this point it enters the quartzite horizon and cuts off some of the lower beds. Consequently to the east of the railway at Ennerdale South these beds cease to form any topographical feature. Their outcrops can, however, easily be followed, and trend in a general south-easterly direction. They abut upon the fault plane, and are separated by a small belt of amygdaloid from the same beds forming the anticline on the farm Cyferfontein No. 191, which occupy its downthrown side.

Daspoort Beds.—The Daspoort Beds are exposed lying normally upon the Timeball Hill beds just described, and extend across the terrain from east to west. They are made up as follows in ascending order :—

Shales.
Amygdaloidal Andesite.
Shales.
Quartzites.

The lower shales give frequent exposures in the beds of the various spruits which traverse this horizon. They are well bedded and usually somewhat weathered, showing red, brown, and yellow colours, with somewhat friable texture. The unweathered shale is blue to brown in colour, with occasional grey bands.

The amygdaloidal andesite occupies a broad belt, stretching across the terrain from west to east. It is considerably narrower on the western border of the area than further east. This is due to the fact that the beds are normally situated in the west, with a uniform dip of some 15 degrees to the south, while to the east the dip decreases and the beds begin to feel the effect of the synclinal structure and change in direction of strike, which is so marked a feature of the eastern portion of the area. The surface width thus increases from about one and a half miles on Kraalkop No. 290 to seven miles through Wildebeestfontein No. 406. The amygdaloid varies from a compact, close-grained rock, composed almost entirely of tiny needles of hornblende and without amygdales, to a rock in which the quartz-filled amygdales are as large as a hazel nut. It differs in no respect from other exposures of the same horizon in the Pretoria, Rustenburg, and Marico Districts. The shales which overlie the andesite are similar to those on which it rests, and are followed by the quartzites which form the uppermost horizon of the Daspoort Beds. The dip is about 10 degrees, and the topographical feature formed by these quartzites bears no comparison to that due to the quartzites of the Timeball Hill horizon. They form a low ridge which, from the north, shows a long slope capped by lines of weathered boulders. The escarpment is nowhere high or imposing, while from the south the ridge has an elevation of perhaps 100 feet above the valley at its base. The quartzites are white and sugary, with dark brown bands among the lower beds.

Magaliesberg Beds.—These are only represented in the south-western corner of the area, and consist entirely of shale beds which show few outcrops. They produce a flat and monotonous type of scenery, which extends southwards as far as the Losberg.

Karroo System.

On the surface the only sign of any rocks overlying the Transvaal System is furnished by a rounded swelling bult which rises from the farm Zuurbekom No. 8 through Syferfontein No. 32 and Waterpan No. 17 towards the Gatsrand on the south. Occasional flat boulders of a coarse sandstone, almost embedded in the surface soil, are to be found on Waterpan, but it is very doubtful whether these represent Karroo grits, especially taking into account the evidence of the various boreholes which have been put down on Syferfontein, in none of which is any rock found similar to these. Probably they represent fragments of disintegrated quartzite boulders derived from the neighbouring Gatsrand.

Boreholes have been put down on Syferfontein and Zuurbekom by the Randfontein Estates, Ltd., to define the coal-bearing area, and the cores afford good sections through these rocks. These boreholes show that the sequence of the rocks of the Karroo System as here developed consists of a series of soft shales, with bands of shaly sandstone, divided into an upper and lower division by the coal-bearing horizon. The upper shales are black and micaceous, alternating with sandy varieties; the lower shales are light and dark coloured. Between the two is a thick seam of coal, underlain by over 100 feet of shale, with narrower coal seams interbedded with coaly shale and sandstone. The upper black shales are overlain by from 50 to 100 feet of yellow pot-clay, and the lower shales are separated from the Dolomite, which they unconformably overlie, by a thin bed of conglomerate.

The area coloured as Karroo on the map marks the limits of the uppermost bed, namely pot-clay, the lower and coal-bearing beds being confined apparently to a series of steep depressions in the old Dolomite land surface or lake bottom, which are being defined by the boring operations above referred to. In the absence of any definite outcrops over the area covered by these rocks, the geological boundary line was arrived at by drawing a line joining up the last chert outcrops around the edge of the Karroo rocks. This line probably slightly exaggerates the area of the latter.

Igneous Rocks.

Intrusions.—The igneous intrusions in the area are confined to the sheets of diabasic rock which are found here, as elsewhere in the Pretoria Series, lying parallel to the bedding planes of the shales and quartzites. They are in no way remarkable, and consist of fairly basic plagioclase with hornblende as chief constituents.

Flows.—The amygdaloidal andesite, which occupies a medial position in the sequence of the Daspoort beds and represents a contemporaneous flow, has been dealt with under the heading of Daspoort beds.

Economic.

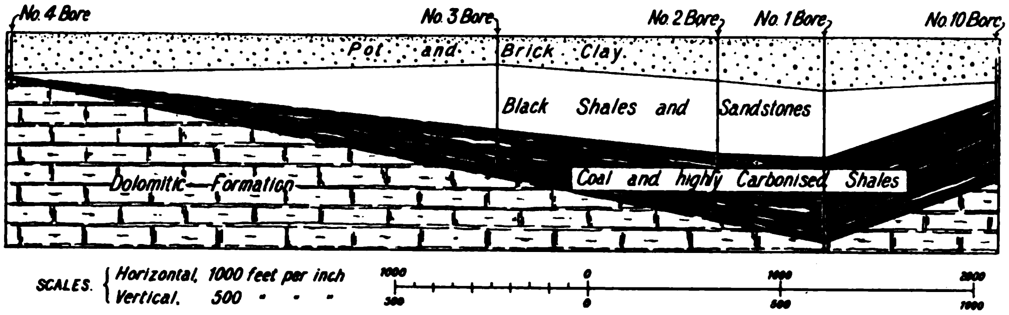
Syferfontein Colliery.—This coal mine is situated in the Karroo area above described, and the extent of the actual coal deposit has been defined by means of a series of boreholes. The sequence of beds, as shown by the No. 10 borehole core, is as follows in descending order:—

Surface soil	22	feet
Yellow pot-clay	88	,,
Black shales, with shaly sandstone	45	,,
Coal	38	,,
Coal with shale bands and shaly coal and sandstone	120	,,
Light and dark shales	53	,,
Conglomerate and shales	6	,,
Dolomite	—	
	372	feet

The actual coal beds seem to have been deposited in steep depressions, of which the one containing the present Syferfontein Coal Mine has been shown, by means of boreholes, to consist of a basin of an elongated oval form, of which the longer axis trends roughly north-east and south-west. The length of the axis from the northern boundary of Syferfontein is 5160 feet, as shown on Section 1 of the accompanying text figure.

SECTIONS FROM THE SYFERFONTEIN COALFIELD, ON SYFERFONTEIN No. 32, KRUGERSDORP.

SECTION No. 1.


No. 4 Bore
No. 3 Bore
No. 2 Bore
No. 1 Bore
No. 10 Bore
Pot and Brick Clay
Black Shales and Sandstones
Coal and highly Carbonised Shales
Dolomitic Formation
SCALES. Horizontal, 1000 feet per inch
Vertical, 500 feet per inch
1000
0
1000
2000
500
0
500
1000

SECTION No. 2.

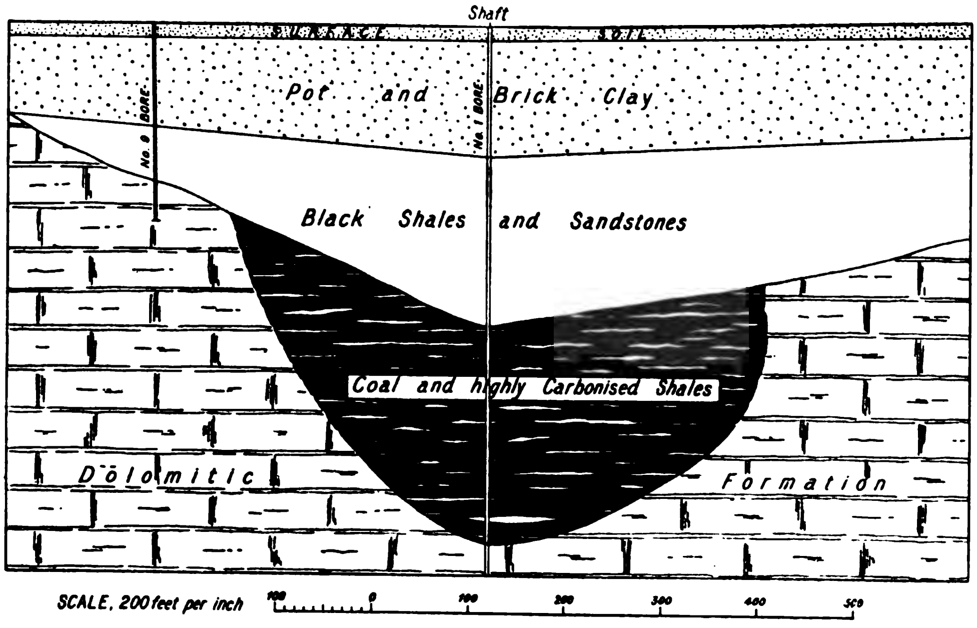


Fig. 6.

The deepest portion of the basin is immediately under the main shaft, and measures 562 feet before reaching the Dolomite.

The Cross Section No. 2 shows a width of the coal-bearing rocks of some 500 feet, and the sides of the basin are very steep, as seen in the text figure.

The basin gradually shallows to the south-west (see Section 1). No fossils have been found in these beds, and it is unlikely that the carbonaceous matter which afterwards formed the coal is of local origin. The shales overlying the coal have considerably greater horizontal development than the coal itself. The coal is bituminous and inclined to be soft.

The mine was not accessible at the time of the visit of the writer, whose thanks are due to Mr. L. C. Rogers, departmental engineer of the Randfontein Estates, for the above information concerning the mine, for the sections here reproduced, and also for his courtesy in showing him over the property.

VI.

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W. J. Hosking	IV 503	Arsenopyrite	Pretoria.
G. Brown	IV 505	Tin ore	Waterberg.
Inspector of Mines, Zululand	IV 506	Columbite tantalite	Zululand, Natal.
J. Dampier Green	IV 507	Phosphate rock	Natal.
Chas. Hassard	IV 508	Sphene granite	Selati.
	IV 509	Mica	Zoutpansberg.
S. M. T.	IV 510	Sandstone	Zuurfontein.
A. J. Burger	IV 511	Smaltite	Waterberg.
V. E. Carlsson	IV 512	Fluor spar	Marico.
Dr. Celliers	IV 513	Tin ore	Waterberg.
R. Sewells	IV 515	Tin ore	Swaziland.
C. M., Orange Free State	IV 516	Epsomite	Orange Free State.
H. Austin	IV 519	Vesuvianite	Bechuanaland.
C. E. Barrett	IV 520	Scheelite	Zoutpansberg.
G. Brown	IV 522	Scheelite	Waterberg.
L. Krantz	IV 525	Baryta	Lydenburg.
E. J. Lawrence	IV 528	Gold ore	Zoutpansberg.
J. D. Cunningham	IV 530	Verdite, with visible gold	Barberton.
J. Zurcher	IV 532	Galena	Zoutpansberg.
— Rudolph	IV 534	Nickel ore	Waterberg.
J. Vosloo	IV 537	Chalcopyrite	—

SAMUEL M. TWEDDILL,
Curator, Geological Survey

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Zone 6, Col. 7, with Map.
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APPENDICES

APPENDIX A.

Table showing the Crushing Strength of various South African Sandstones, Granites, etc.

SANDSTONES.

No. of Sample.	Description.	Locality.	Position.	Load in pounds per square inch at initial fracture.	Load in pounds per square inch at final fracture.	Remarks.
700a	Fine-grained red sandstone	Buiskop	—	2,856	15,568	Very hard and plucky; condemned for New Post Office, Pretoria.
700b	,, ,,	,,	—	17,976	19,376	
701	,, ,,	,,	—	13,776	15,008	Medium quality, exposed about six years; used in Town Hall, Pretoria.
702a	,, ,,	,,	—	7,560	7,840	Fairly soft variety; fresh from quarry; used in New Post Office.
702b	,, ,,	,,	—	6,384	8,288	
703	Grey sandstone	Flatpan	Edge	—	8,512	—
703	,,	,,	Bed	—	8,260	—
736	Yellowish sandstone; "New Flatpan"	Steenpan Quarry	Bed	—	6,132	—
717a	Hard laminated sandstone "Klippan"	Flatpan Quarry	Bed	9,800	9,856	Sample supplied by Public Works Department.
717b	,, ,,	,,	Edge	7,896	7,952	
—	Greyish sandstone	Steenpan	Bed	—	7,261	Sample tested at South African College, Capetown, 3⅛ in. cube.
696	,, ,,	,,	Bed	—	7,728	Hard sample, with black streaks, as used for New Law Courts, Johannesburg.
K 1a K 3b K 3c	,, ,,	,,	Bed	—	4,414	Average of three tests; soft variety; exposed about a year.
K 1b–3a.	,, ,,	,,	Edge	—	2,954	Average of four tests; soft variety.
714	White sandstone	Kromdraai, Balmoral.	Bed	—	7,056	Sample exposed at side of quarry about two years.
715	Light-grey sandstone.	,, ,,	Bed	8,512	8,568	Sample supplied by Public Works Department.
716	,, ,,	,, ,,	Bed	—	7,392	Sample exposed from two to three years.
705	Fine-grained white sandstone	Middlekop, near Pienaars River	—	9,380	9,464	From large block exposed at side of quarry about one year.
705b	,, ,,	,, ,,	—	10,416	11,480	From quarry; hard variety.
705a	,, ,,	,, ,,	—	12,656	13,160	From block exposed about nine months in Public Works Department's yard.
705c	,, ,,	,, ,,	—	—	5,600	Sample supplied by owners.
705c	,, ,,	,, ,,	—	3,808	3,920	
—	,, ,,	Ladybrand	—	8,400	8,680	—
712a	,, ,,	Waterval	Bed	—	9,744	Sample out of quarry for several years.
712b	,, ,,	,,	Edge	—	8,652	
E. R.	White sandstone	Elands River	Bed	—	7,168	As used for Minnaar Street Bridge, Pretoria.
E. R. 3.	,, ,,	,,	Bed	—	9,184	—
E. R. 4.	Grey sandstone	,,	Bed	—	9,688	—
697	,,	Ermelo	Bed	—	8,344	Sample out of quarry several years; hard variety.
713	White sandstone	Vereeniging	—	—	9,128	A long time out of quarry.
710	Yellowish sandstone, with red streaks	Hammanskraal.	Bed	—	8,652	Freshly quarried; as used for New Court House, Hammanskraal.
711	Yellowish sandstone, with yellow streaks	,,	Bed	—	8,652	
709	Yellowish, rather coarse sandstone	Stinkwater	Bed	—	10,528	Out of quarry for several years.

SANDSTONES—(*continued*).

No. of Sample.	Description.	Locality.	Position.	Load in pounds per square inch at initial fracture.	Load in pounds per square inch at final fracture.	Remarks.
A. 1.....	White sandstone......	Balmoral............	Bed	8,512	8,736	Freshly quarried.
A. 2.....	"	"	Bed	—	7,784	
735*a*.....	White sandstone......	Kleinwater, Balmoral.	Bed	7,336	7,728	Freshly quarried.
735*b*......	"	" " .	Edge	6,664	6,748	
B. 1 and 2	"	Near Crown Douglas Colliery, Balmoral	Bed	5,852	6,188	Average of two tests; contains much decomposed felspar.
733*a*.....	Grey sandstone.......	Macintosh's Quarry, Boksburg	Bed	8,624	8,904	Fairly recently quarried; very hard.
733*b*......	"	" "	Edge	7,000	7,252	
734*a*.....	"	Quarry near Apex Mine, Boksburg	Bed	—	8,400	—
734*b*......	"	" "	Edge	5,600	6,720	—
—	"	Bayswater Quarry, Bloemfontein	Bed	5,600	5,880	Average of two tests; from sample freshly quarried.

GRANITES, ETC.

No. of Sample.	Description.	Locality.	Load in pounds per square inch at initial fracture.	Load in pounds per square inch at final fracture.	Remarks.
718*a*.....	Norite..................	Bon Accord Quarry, north of Pretoria	23,912	28,504	Fresh from quarry.
718*b*......	"	" "	26,950	33,250	
719*a*.....	"	Quarry at side of railway, Onderstepoort	29,100	29,530	
719*b*......	"	" "	25,500	28,900	
720......	Diabase..................	North-west of Melville, Johannesburg	26,500	29,250	Exposed for some time; used in Natal Bank, Johannesburg.
721*a*.....	Grey granite.............	Witkoppen, north of Johannesburg	36,000	36,650	Used in basement portion of Union Buildings.
721*b*......	"	" "	30,700	32,250	
722*a*.....	Pinkish granite, rather coarse	Half-way House, south of Pretoria	19,500	29.200	Used in New Station, Pretoria.
722*b*......	" "	" "	27,000	36,650	
726*a*.....	Coarse grey granite.......	Craighall, north of Johannesburg	25,700	27,050	—
726*b*......	" "	" "	24,250	26,100	—
11*a*......	" "	" "	30,500	33,100	—
728*a*.....	Red granite..............	Twenty miles north of Pretoria	26,100	28,300	—
728*b*......	"	Waterval, north of Pretoria	22,025	23.900	Average of two tests.
732......	"	Hammanskraal...........	23,000	28,320	—

APPENDIX B.

Table showing Specific Gravity, Weight per Cubic Foot, and Absorption of various Sandstones tested in the Laboratory of the Geological Survey.

1. SANDSTONES.

No.	Locality.	Specific Gravity.	Weight per Cubic Foot.	Water Absorbed.
			lb.	Per cent.
696	Steenpan	2·53	158·125	5·5
K. 3	Steenpan (soft variety)	2·48	155·000	5·9
703	Flatpan	2·5	156·25	4·8
703	Flatpan	2·55	159·375	3·6
717	Klippan	2·00	125·000	4·79
714	Balmoral	2·44	152·500	2·65
715	Balmoral	2·56	160·000	4·92
716	Balmoral	2·53	158·125	5·92
700	Buiskop	2·56	150·000	3·8
701	Buiskop	2·47	154·375	4·4
702	Buiskop	2·43	151·975	5·6
705	Middelkop	2·47	154·375	3·69
705A	Middelkop	2·49	155·625	2·77
705B	Middelkop	2·46	153·750	3·86
Lbd.	Ladybrand	2·5	156·259	6·00
712	Waterval	2·57	160·625	4·62
E.R.	Elands River	2·62	163·750	3·00
E.R. 3	Elands River	2·8	175·000	3·3
E.R. 4	Elands River	2·6	162·500	2·4
697	Ermelo	2·5	156·25	3·3
710	Hamanskraal	2·47	154·375	6·84
711	Hamanskraal	2·52	157·500	5·8
709	Stinkwater	2·51	156·875	5·43
713	Vereeniging	2·52	157·500	5·04

2. GRANITES, ETC.

No.		Locality.	Specific Gravity.	Weight per Cubic Foot.
				lb.
718	Norite	Bon Accord Quarry	2·93	183·125
719	Norite	Railway Quarry, Onderstepoort	2·84	177·500
720	Diabase	North-west of Melville, Johannesburg	2·87	179·375
721	Granite	Witkoppen	2·7	168·75
722	Granite	Half-way House	2·44	152·500
726	Granite	Craig Hall	2·63	164·375
728	Granite	Petronella, north of Pretoria	2·6	162·500
R.G.	Granite	Waterval	2·52	157·500

APPENDIX C.

Table showing the different kinds of Stone used in various buildings in Pretoria and Johannesburg.

Stone.	Building.	Remarks.
Steenpan	Netherlands Bank, Pretoria	Built 15–16 years; stone a reddish brown streaky colour, mainly from dust; otherwise has weathered well.
„	Police Barracks, Pretoria; front entrance	Discoloured.
„	Artillery Barracks, Pretoria; building near entrance	Completed early part of 1896; stone marked by reddish horizontal streaks, but very hard and moulding still sharp.
„	Cold Storage Buildings, Schoeman Street, Pretoria	—
„	Marks' Buildings, opposite Market Square, Pretoria	—
„	Bank of Africa, Pretoria	—
„	Boys' College, Rissik, Pretoria	—
„	Normal College, Pretoria	—
„	Lunatic Asylum, Pretoria	Weathered badly; built 5–6 years.
„	Cullinan's Buildings, Johannesburg	—
„	Standard Bank, Johannesburg	Stone in good condition.
„	New Law Courts, Johannesburg	—
„	New Post Office, Pretoria	—
„	New Library and Museum, Pretoria	—
Flatpan	New University Buildings, Capetown	—
„	New Station, Pretoria	—
„	Union Buildings, Pretoria	—
Klippan	New University, Pretoria	—
„	Outer retaining wall, Union Buildings	—
Boksburg	Palace of Justice, Pretoria	Scaled in places, especially staircase at front stained and streaky.
„	Carlton Hotel, Johannesburg	—
„	Oceana Buildings, Johannesburg	—
„	Natal Bank, Johannesburg	Decayed and discoloured.
„	Bank of Africa, Johannesburg	Very streaky; contains large pebbles and flints.
„	Consolidated Buildings, Johannesburg	—
Waterval	John Jack's, Church Street West, Pretoria	—
„	Kirkaldy & Malcolm's, Pretoria	—
„	New Government Buildings, Pretoria	—
„	Fountain Hotel, Pretoria	Pink variety.
„	Railway Bridge, Potgieter Street, Pretoria	—
„	Artillery Barracks, Pretoria; gun sheds, stables, and officers' quarters	—
„	Government Buildings, Pretoria	All colours, very streaky, some weathering badly; columns inside looking well.
„	Van Erkom's Buildings, Pretoria	—
„	National Bank, Pretoria; dated 1892	On the whole has weathered well; moulding and carving in good condition, but blocks in base course have scaled; some stone very streaky and columns on edge.
„	Marks' Buildings, opposite Market Place, Pretoria	—
„	Erasmus Buildings, Pretoria	—
„	Beckett's Buildings, Pretoria	—
„	Buildings in Church Square, Pretoria, above Carlton Bar	Partly from Kirkness and partly from Munro's quarries; latter coarser and variable, weathers badly, and is a dirty colour.
„	Standard Bank, Pretoria	—
„	Normal College, Pretoria; base courses	—
„	New Tram Bridge	—
„	Presbyterian Church, Pretoria	—
„	New University, Pretoria	—

Different kinds of Stone used in various buildings—(*continued*).

Stone.	Building.	Remarks.
Stinkwater..........	John Jack's, Church Street West, Pretoria.........	—
„	Artillery Barracks, Pretoria........................	With Waterval in gun-sheds, stables, etc.; very hard and strong, now a reddish brown.
„	Government Buildings, Pretoria....................	—
„	Beckett's Buildings, Pretoria......................	—
Hammanskraal......	Erasmus Buildings, Pretoria.......................	Coarser than Waterval.
Vereeniging.........	Artillery Barracks, Pretoria; main building.......	Often streaky.
„	Pretoria Building Society's Offices.................	With Buiskop.
„	Café Royal, Church Street, Pretoria...............	—
„	Palace of Justice, Pretoria; inside columns........	—
„	Marks' Buildings, Capetown.......................	—
Elands River........	Crow's Buildings, Pretorius Street, Pretoria........	—
„	Minnaar Street Bridge, Pretoria	—
„	Boys' College, Rissik, Pretoria.....................	—
Buiskop............	Pretoria Building Society's Buildings, Pretoria.....	With Vereeniging.
„	Municipal Offices, Pretoria........................	—
„	Bank of Africa, Pretoria; lower courses...........	Rock faced.
„	Post Office, Pretoria; inside work................	—
„	Station, Pretoria; inside work....................	—
„	Union Buildings, Pretoria; inside work...........	—
„	Eckstein's Buildings, Johannesburg; lower courses.	—
Wolvehoek..........	Pass Office, Johannesburg........................	Variable and streaky; tends to weather badly, with soft patches, and gets very dark.
Koekoemoer and Machavie	English Cathedral, Johannesburg..................	Machavie coarse, often with pebbles; Koekoemoer finer, yellowish; neither weather well.
„ „	St. Mary's Buildings, Johannesburg...............	—
Balmoral...........	Presbyterian Church, Schoeman Street, Pretoria; pulpit	—
„	New Prison, Pretoria............................	—
„	Terrace in Church Square, just below African Board Buildings	—
Norite..............	New Post Office, Pretoria........................	Very durable and hard.
Melville Diabase.....	Natal Bank, Johannesburg; base courses..........	—
Granite, Half-way House	Steps, New Government Buildings, Pretoria........	—
„ „	New Station, Pretoria............................	—
Syenite, Bank.......	National Bank Buildings, Pritchard Street, Johannesburg, up to plinth level	—
„ „	Steps of Post Office, Johannesburg................	—
„ „	Steps of Palace of Justice........................	—

PAGE
Elandslaagte 1312, Lydenburg 44, 48
Elands River, building stone from 19
Elandspruit 462, Lydenburg 51
Elsburg Beds 35
Ennerdale South Station 83
Enzelberg Quartzite 78
Ermelo, building stone from 19
Evaton Station 83
Eudialite 59, 60

Faulting in Lower Witwatersrand System 28, 29, 30, 31, 32
Faults, Marico and Rustenburg Districts ...68, 69, 76, 77, 78, 84, 85, 86
Feest Kop 55
Felsite 57, 60
Ficksburg, Orange Free State, building stone from 20
Field work, distribution of 15
,, ,, summary of, for the year 15-17
Flagstones 75
Flatpan stone 18
Flows, igneous 88
Folding, Langerman's Kop Beds 35
Folding, Witwatersrand System 30, 32, 34
Folds, Marico and Rustenburg Districts 68, 76, 77, 84, 85

Gabbro 54
Galg Kop 42, 56
Garnet 75
Gatsrand 83
Goedehoop 438, Rustenburg.................. 70, 79
Goedgedacht 279, Middelburg 57, 61
Goedgevonden 843, Rustenburg 79
Gold, Mapochs Country 56
Government Reef Series 27, 33
Granite, Bushveld 53, 56
,, Older 25, 30
,, ,, on Rietfontein 145 31
Granites, used for building purposes ... 20
Granitic apophyses 56
Granophyre 56, 57
Griquatown Beds 55
Groot Zuikerbosch Kop 53

Halfway House, granite quarried at 20
Hamanskraal, granite quarried near ... 20
Heimwehberg 255, Marico 73
Holfontein 667, Rustenburg 76
Hornblende 54, 57, 58
,, granite 58
,, schist 60
Hornfels 52
Hospital Hill quartzites 26, 27, 28, 32, 33
Houtenbek 191, Lydenburg 45, 47, 51, 55
Hypersthene 55

Injected hornfels 52
Intrusion 75, 88
Intrusive rocks, Pretoria Series 53

Jachtfontein 99, Potchefstroom 87
Jans Kop 69

PAGE
Kaffirskraal 62, Middelburg 56
,, *630, Lydenburg* 45, 49
Kameelnek 654, Rustenburg 74
Karreekraal 219, Lydenburg 51
Karroo System 88
Kensington, Johannesburg 26, 29, 33
Klip River 42, 45, 46, 50, 83
Klipbankspruit 1443, Lydenburg 44, 45
Klippan 311, Rustenburg 77
Klippan building stone 18
Klip River 1314, Lydenburg 42, 44, 46
Koedoesfontein 385, Rustenburg 74
Kola Peninsula 60
Konterdanskloof 915, Lydenburg 49, 54
Kopje Alleen 46, 55
Koppieskraal 1360, Lydenburg 48
Kromdraai (near Balmoral), building stone from 19
Kruis River 50, 56
Kruisfontein 1033, Lydenburg 51

Labradorite 54
Ladybrand, Orange Free State, building stone from 20
Lakenvley 1081, Lydenburg 48
Langerman's Kop 26, 30, 33, 34
,, ,, Beds 34, 35
Leeuwfontein 96, Middelburg 50, 56
Leeuwkop 26, Rustenburg 79
Lekkerlach 253, Marico 69
Limestone 52
Logaga 144, Marico 74
Lunsklip 1446, Lydenburg 44, 45, 46, 48
Lunsklip Quartzite 45
Lydenburg District, summary of field work in the 16
Lydenburg Dorp River 48, 52

Mabieskraal 620, Rustenburg 76, 77
Magaliesburg Beds 74, 75, 76, 88
,, Quartzites 47, 48, 49, 50
Magmatic differentiation 58
Magneet Kop 56
Magnet Heights 41, 55, 56
Magnetite 55
Mapochs Country 41, 42, 46, 47, 55
,, River 41, 42, 45
Maps completed during the year 4, 15, 20, 21
Maraisburg 28, 33
Marico Bushveld 64, 66
,, District, summary of field work in the 16
,, River 67
Matlapynsberg 75, 76
Melville Township, diabase from 20
Metamorphosed calcareous rocks 52, 53
,, quartzite 49
,, shales 51, 52
Meyerton Station 84
Middelburg District, summary of field work in the 16
Middelfontein 128, Johannesburg 29
Middelkop (Springbok Flats), building stone from 20
Middelrand 254, Marico 73
Misgund 34, Rustenburg 79
Modderspruit 1361, Lydenburg 45, 48, 49
Morgenzon 1445, Lydenburg 48
Muscovite 50

Naauwpoort 1432, Lydenburg 45, 48
Nepheline 59, 60
,, syenite 59, 70, 79

PAGE
Nooitgedacht 35, Rustenburg ... 77
,, *274, Heidelberg* ... 86
Norite ... 55, 56, 78
,, used for building, etc. ... 20
Notwani River ... 67, 71

Okkerskraal 3, Rustenburg ... 73
Olifants River ... 41, 46, 56
Olivine ... 54
Onderstepoort, quarry at ... 20
Ongeluk Series ... 55
Onverwacht 142, Marico ... 66
,, *210, Lydenburg* ... 44, 45, 47, 48
Orange Grove Quartzites ... 25, 31, 32
Orthoclase ... 57, 58
Oshoek 1442, Lydenburg
42, 45, 46, 48, 49, 50, 51, 52
Oud Thomas zijn Loop ... 75

Paardeplaats 913, Lydenburg ... 48, 49
Paardekloof 99, Middelburg ... 56, 58
Paardekop ... 43, 44, 46, 56, 57
Pagskraal 137, Marico ... 78
Pegmatite ... 56
Pienaars River, stone quarried near ... 20
Plagioclase ... 53, 54, 58
Pokwani ... 41, 43, 44, 46, 56, 57
Potchtfstroom District, summary of field work in the ... 17
Potgietersrust ... 49
Potspruit 1188, Lydenburg ... 45
Pretoria Quartzites ... 47
Pretoria Series, Dwarsberg ... 71, 86
,, ,, Lydenburg ... 47
,, Shales ... 51
Publications issued during the year ... 20, 21
Pyroxene ... 50, 51, 52
,, foyaite ... 59
,, ,, pegmatite ... 59
,, ,, porphyry ... 59
Pyroxenite ... 55, 78

Quartz-augite-monzonite porphyry ... 58

Rampapians Poort 710, Rustenburg ... 69
Ramsay ... 60
Rand Collieries, quarry near the ... 19
Red Granite ... 56
Rietfontein 145, Boksburg ... 29, 36
,, ,, ,, granite on ... 31
,, *451, Middelburg* ... 58, 59
,, *927, Rustenburg* ... 76
Rietfontein Pan, quarry at ... 19
,, Series ... 26, 36
Roads, Rustenburg and Marico Bushveld ... 65
Roedebloom 466, Rustenburg ... 79
Rogers ... 55
Roodepoort 49, Krugersdorp ... 85, 86
,, *252, Heidelberg* ... 83
Rooiklip 463, Lydenburg ... 51
Rooikraal 14, Middelburg ... 56
Roos Kop ... 42
,, Senekal ... 41, 42, 43, 45, 46, 50, 55, 56
Ruitjesvlakte 240, Marico ... 69, 72, 74
Rustenburg Bushveld ... 64, 66
,, District, summary of field work in the ... 16, 17

Santa Siding ... 46
Schaapkraal 442, Lydenburg ... 45, 48, 49, 50
Schoemans Kloof ... 44

PAGE
Schoongezicht 416, Rustenburg ... 69
Schuurwebergen ... 54
Sekukuni's Mountains ... 42, 43, 46, 47, 53
Serpentine ... 52, 53
Serpentinized limestone ... 53
Shales ... 73, 74
,, altered ... 74, 75, 77
,, graphitic ... 74, 75
Silikaats Kop ... 74, 76, 77
Sillimanite ... 50
Sphene ... 59, 60
Spitzkop 463, Middelburg ... 43, 46, 53, 58, 60
Steelpoort River ... 41, 42, 43, 46, 47
,, ,, Valley ... 41, 42, 45, 46
Steenkampsbergen ... 41, 42, 44, 45, 46, 48, 51
Steenpan stone ... 18
Steynsdrift 16, Lydenburg ... 46, 56, 57
Stoffberg ... 43, 46, 58
Structure, Dwarsberg ... 68, 74
,, Klip River syncline ... 84, 85
,, Marico Bushveld ... 66, 68, 78
Syenite ... 70, 79
,, used for building purposes ... 20
Syferfontein Colliery ... 88
Syferfontein 32, Krugersdorp ... 85, 88
,, *625, Rustenburg* ... 76

Tambootiesrand 186, Rustenburg ... 77
Tautesberg ... 43, 46, 56, 57
Tauteshoogte ... 46, 47, 58
Timeball Hill Beds ... 71, 72, 86
Tinguaite ... 60
Toit ... 55
Tonteldoos ... 46, 54
,, Spruit ... 42
Transvaal System ... 70, 85
Tygershoek 1328, Lydenburg ... 43

Uitkyk 36, Middelburg ... 57, 58
,, *277, Rustenburg* ... 78
Uitloop 1543, Waterberg ... 49
Uralite ... 53
Urtite ... 59, 60

Vaalkop ... 43, 46, 57
Van Tonder's Hoek 245, Marico ... 69, 70, 72
Varkensfontein 319, Heidelberg ... 84
Ventersdorp System, Dwarsberg ... 69
Vereeniging, building stone from ... 19
Verloren Vley 1316, Lydenburg ... 44, 45, 46, 48
Vermont Siding ... 50
Vesicular andesite ... 54
Vygehoek 1194, Lydenburg ... 45, 46, 48, 49

Wanhoop 7, Lydenburg ... 45, 46, 48, 50
Waterpan 17, Krugersdorp ... 85, 88
Water supply, Lydenburg District ... 45
Water supply, Rustenburg and Marico Bushveld ... 67
Waterval, building stone from ... 19
,, River ... 44, 45, 46, 48, 49, 50
Waterval 79, Krugersdorp ... 26, 34
,, *652, Lydenburg* ... 45
Welgevonden 40, Middelburg ... 74
,, *241, Marico* ... 74
Wemmershoek 315, Lydenburg ... 50, 51, 52
Windhoek 443, ,, ... 47
Wintershoek 19, Middelburg ... 50, 54
Witfontein 306, Rustenburg ... 74
Witkliegat 28, Krugersdorp ... 86
,, *273, Marico* ... 69

PAGE
Witklip 26, Lydenburg 44
Witkop 66, Heidelberg 85
Witkopje 157, Boksburg 31
Witkoppen, granite from 20
Witpoort 26, Middelburg 46, 54
Witrand 44, 48
Witwatersrand Central 25-37
,, ,, geology of 26
Witwatersrand Central, physical features 25
Witwatersrand District, summary of field work in the 15-17
Witwatersrand System, lower 27
,, ,, ,, faulting 28-30, 31, 32
,, ,, ,, folding . 30, 34

PAGE
Xenoliths 51

Zoisite 50
Zuurbekom 8, Krugersdorp 88
Zwartfontein Hills 66
Zwartkop 42
,, Spruit 45, 54
Zwartkopfontein 328, Marico 68-71
Zwartrand 55

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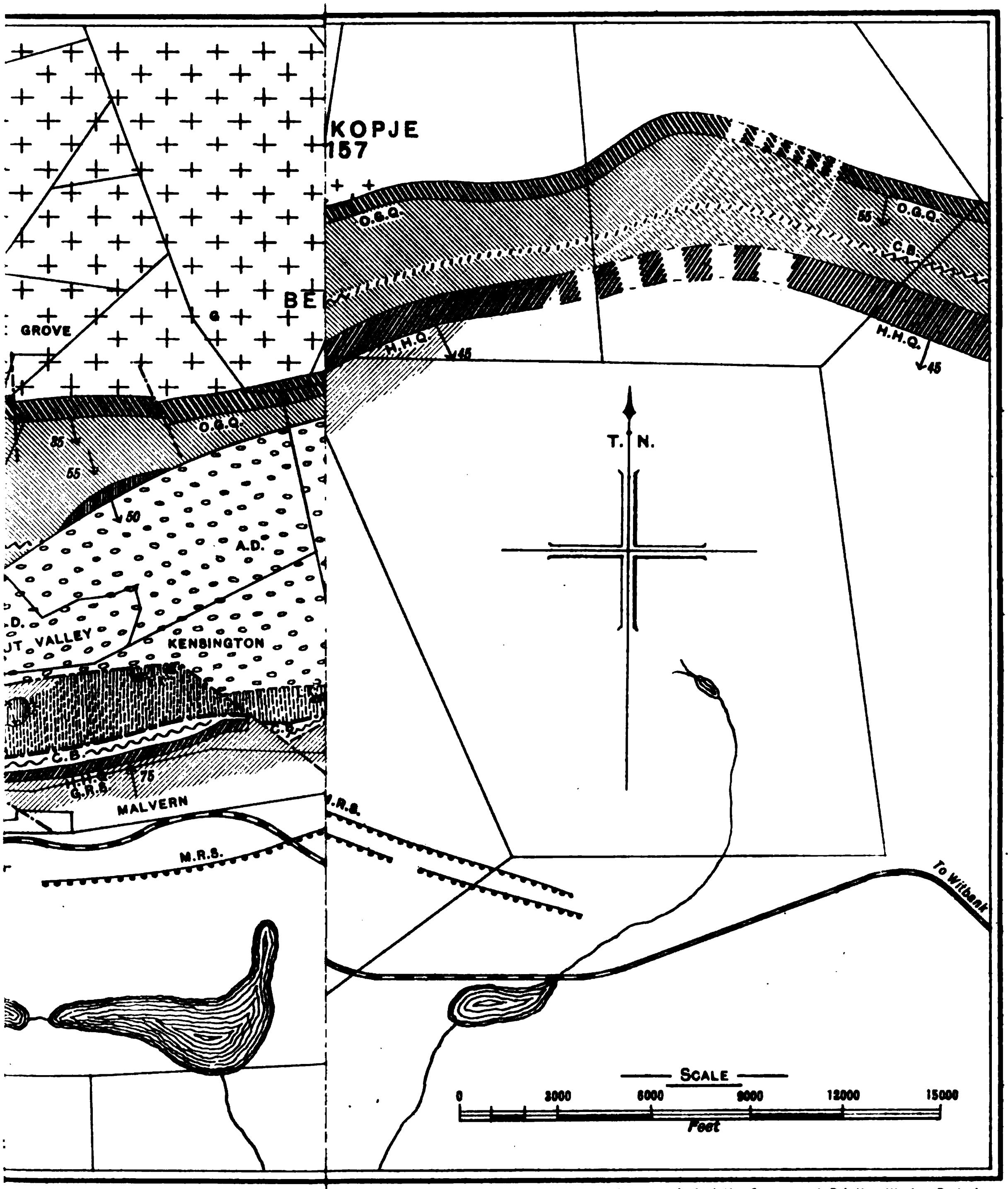

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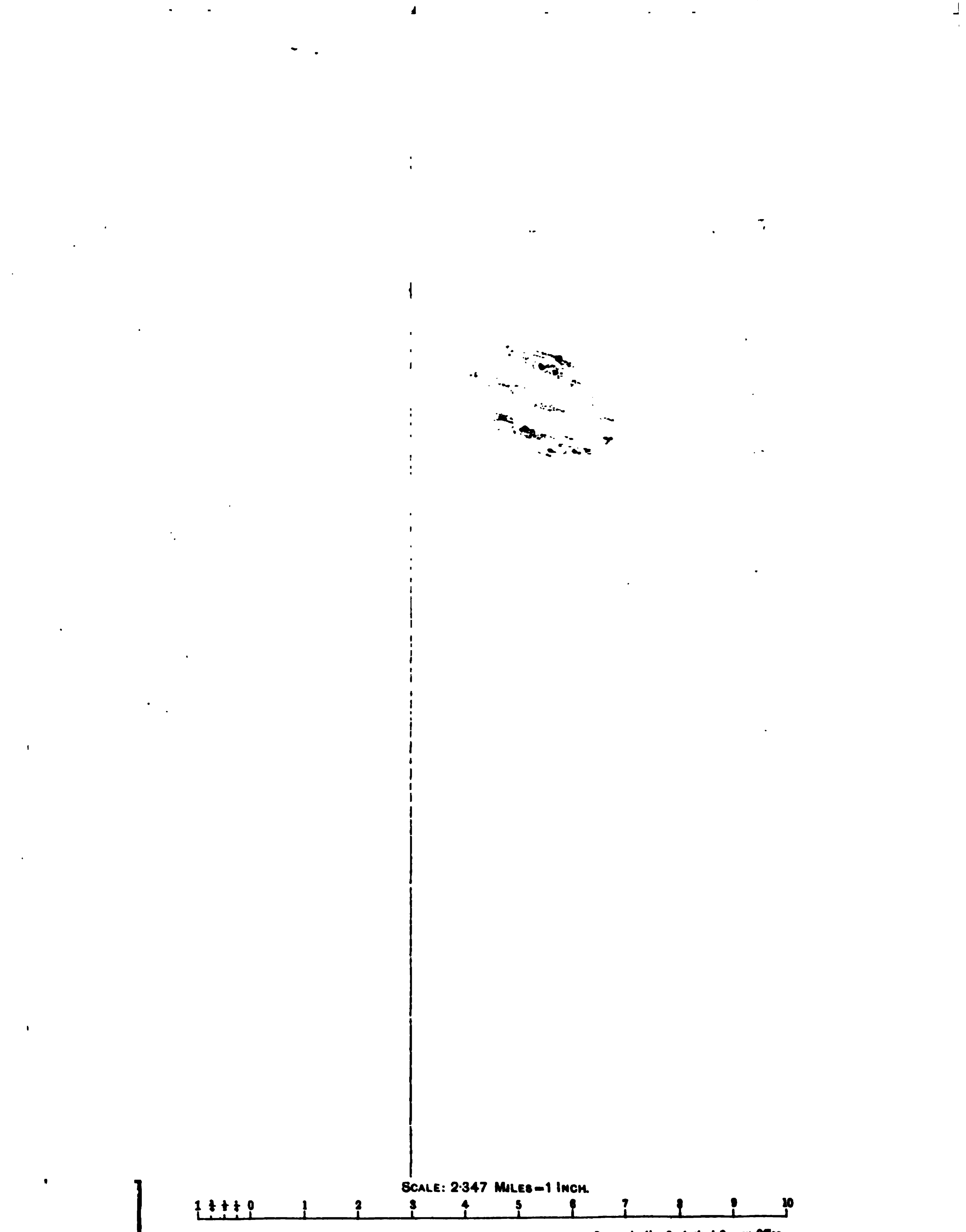

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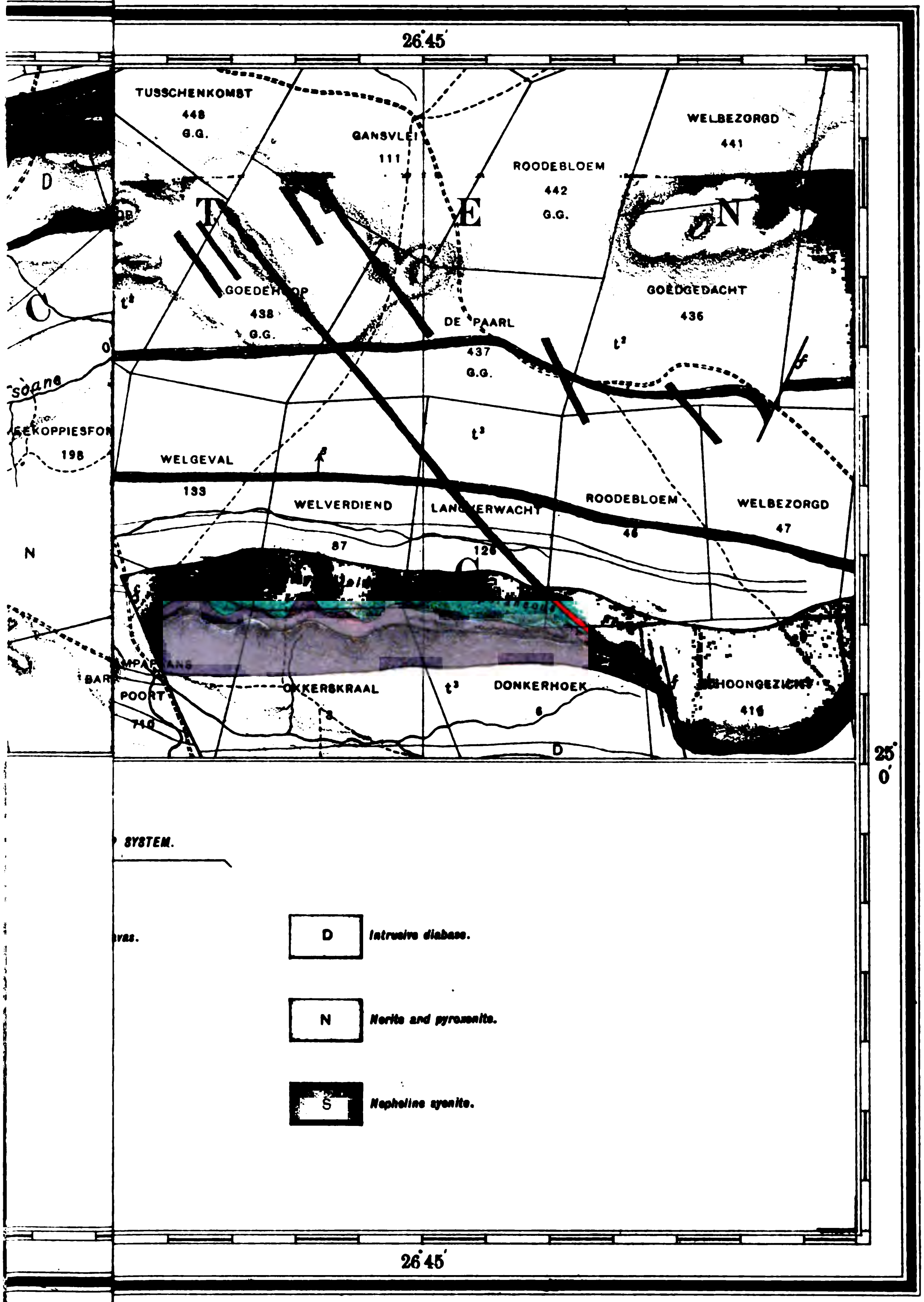

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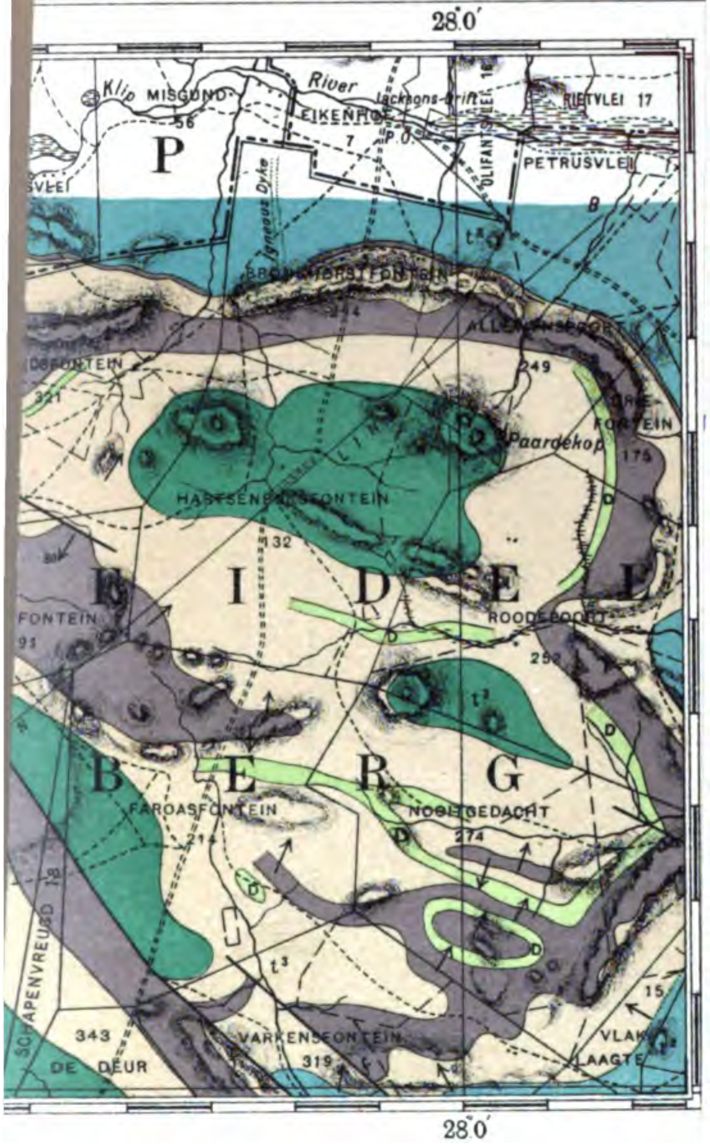

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